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(54) **USER INTERFACES FOR HVAC SCHEDULE DISPLAY AND MODIFICATION ON SMARTPHONE OR OTHER SPACE-LIMITED TOUCHSCREEN DEVICE**

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None
See application file for complete search history.

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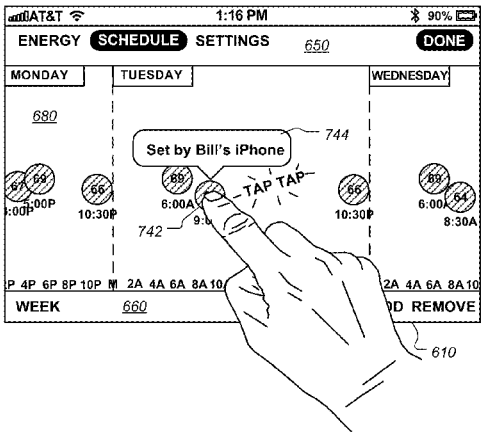
(57) **ABSTRACT**

A novel small format touch screen user interface for displaying, adding and editing program setpoints is described. When editing a setpoint the user's input is constrained such that the user can only alter one parameter (either time or temperature). As soon as the user begins to drag a setpoint icon in either a horizontal (i.e. adjusting time), or vertical (i.e. adjusting temperature), the other parameter is constrained. Additionally, the disclosed user interface includes displaying information as to how the setpoint was most recently added or adjusted. For example the display can be used to indicate whether a setpoint was added or adjusted (1) on the thermostat itself; (2) by an automated learning algorithm; (3) by a user on a web client; or (4) by a user using a mobile client (such as a smart phone or tablet PC). Further, the name of the particular device is also displayed if known.

20 Claims, 20 Drawing Sheets



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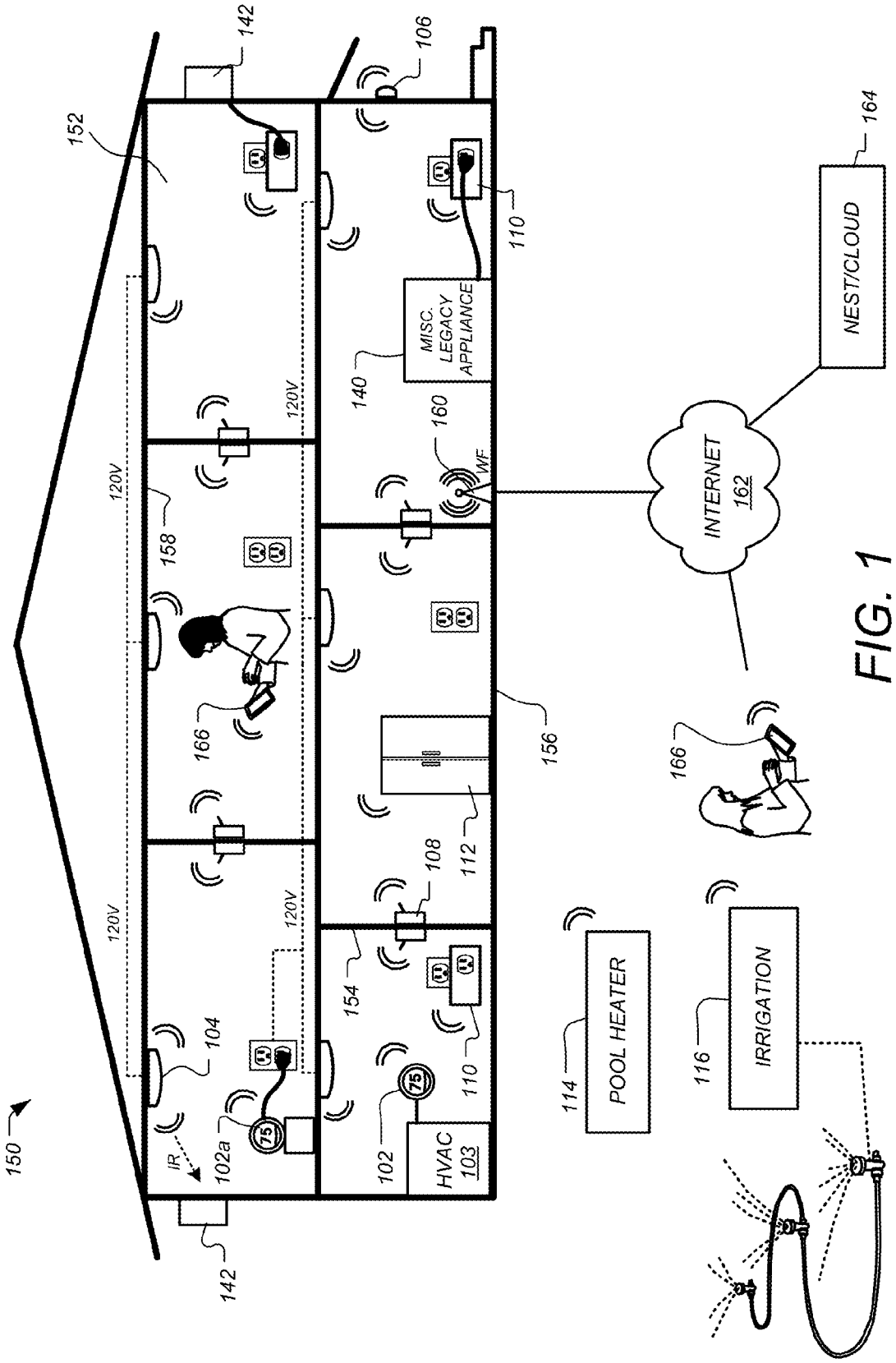
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152
142
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MISC. LEGACY APPLIANCE
140
160
WF
INTERNET 162
NEST/CLOUD
164
120V
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166
156
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112
154
104
102a
IR
102
HVAC 103
POOL HEATER
114
IRRIGATION
116

FIG. 1

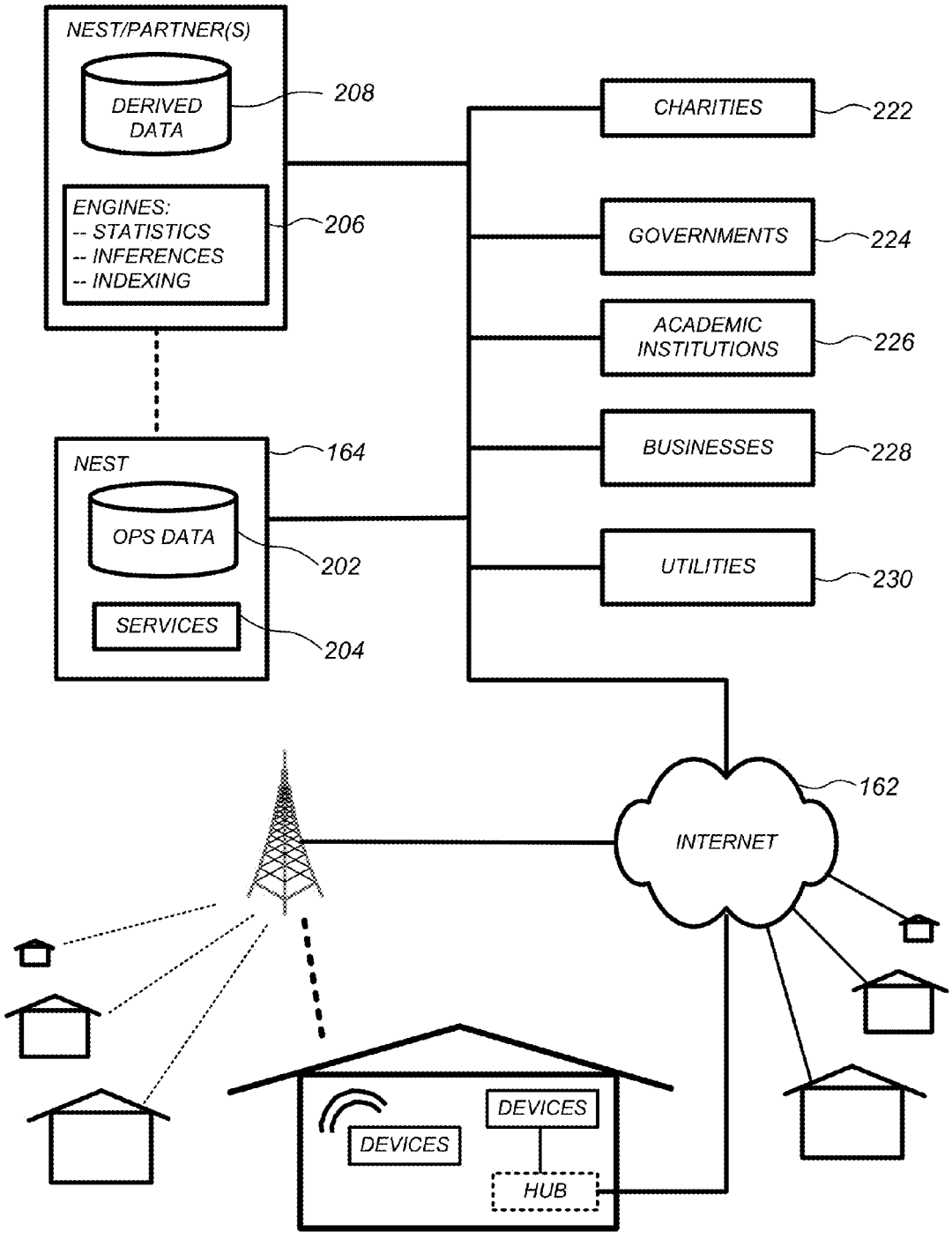

NEST/PARTNER(S)
DERIVED DATA
208
ENGINES:
-- STATISTICS
-- INFERENCES
-- INDEXING
206
NEST
164
OPS DATA
202
SERVICES
204
CHARITIES
222
GOVERNMENTS
224
ACADEMIC INSTITUTIONS
226
BUSINESSES
228
UTILITIES
230
INTERNET
162
DEVICES
DEVICES
HUB

FIG. 2

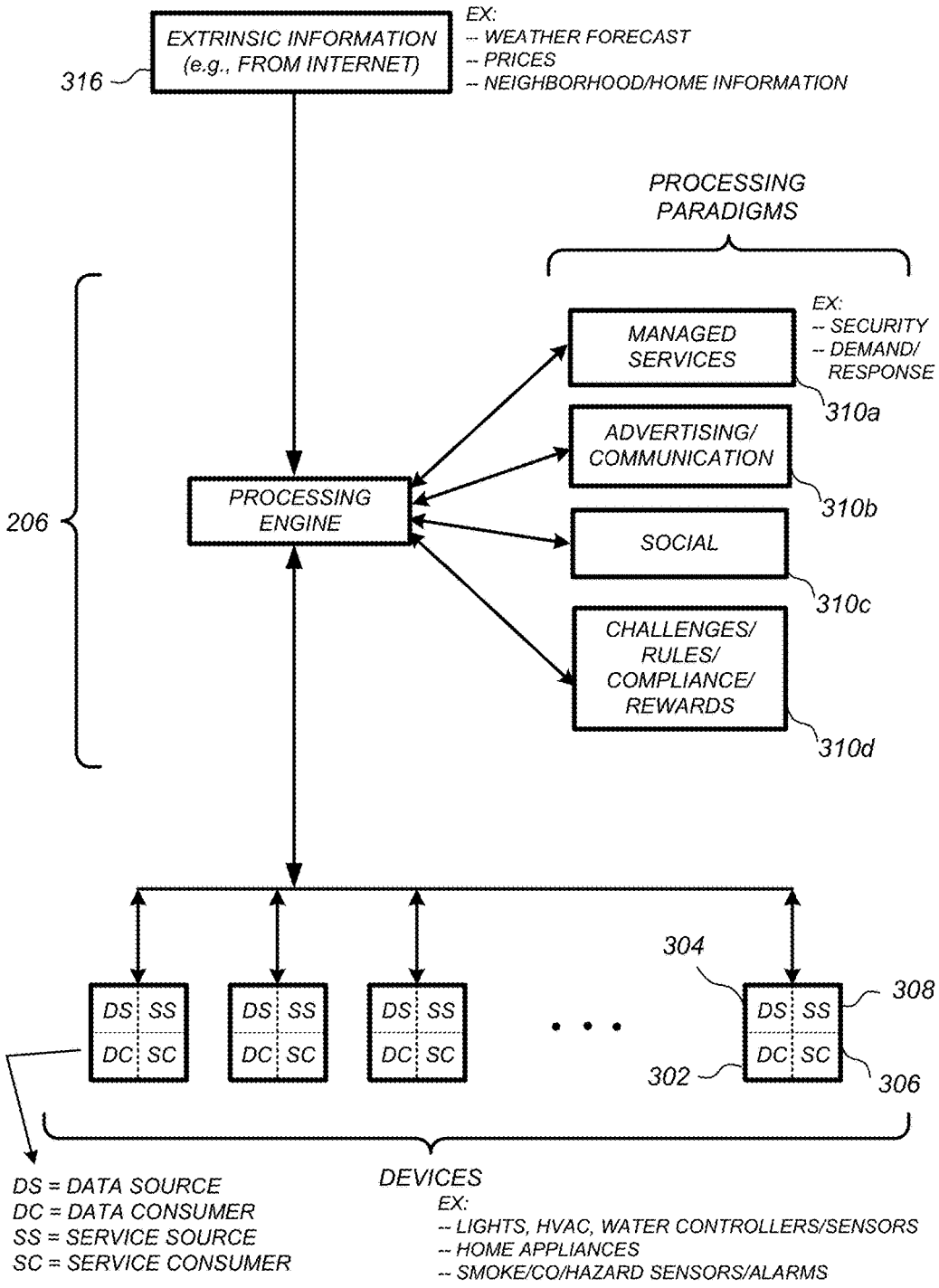
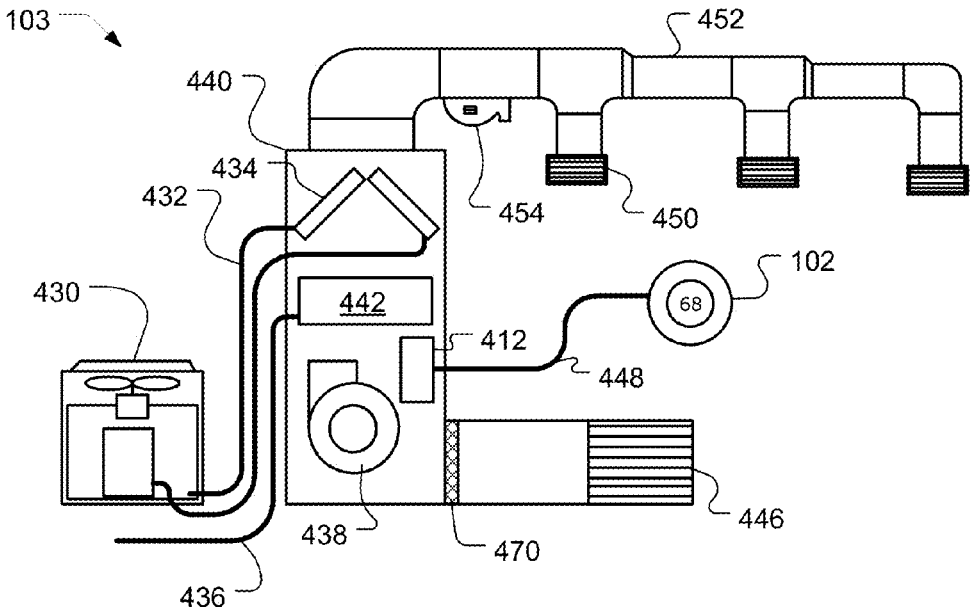

EXTRINSIC INFORMATION (e.g., FROM INTERNET)
316
EX:
-- WEATHER FORECAST
-- PRICES
-- NEIGHBORHOOD/HOME INFORMATION
PROCESSING PARADIGMS
206
PROCESSING ENGINE
MANAGED SERVICES
EX:
-- SECURITY
-- DEMAND/ RESPONSE
310a
ADVERTISING/ COMMUNICATION
310b
SOCIAL
310c
CHALLENGES/ RULES/ COMPLIANCE/ REWARDS
310d
304
308
302
306
DS SS
DC SC
DS = DATA SOURCE
DC = DATA CONSUMER
SS = SERVICE SOURCE
SC = SERVICE CONSUMER
DEVICES
EX:
-- LIGHTS, HVAC, WATER CONTROLLERS/SENSORS
-- HOME APPLIANCES
-- SMOKE/CO/HAZARD SENSORS/ALARMS

FIG. 3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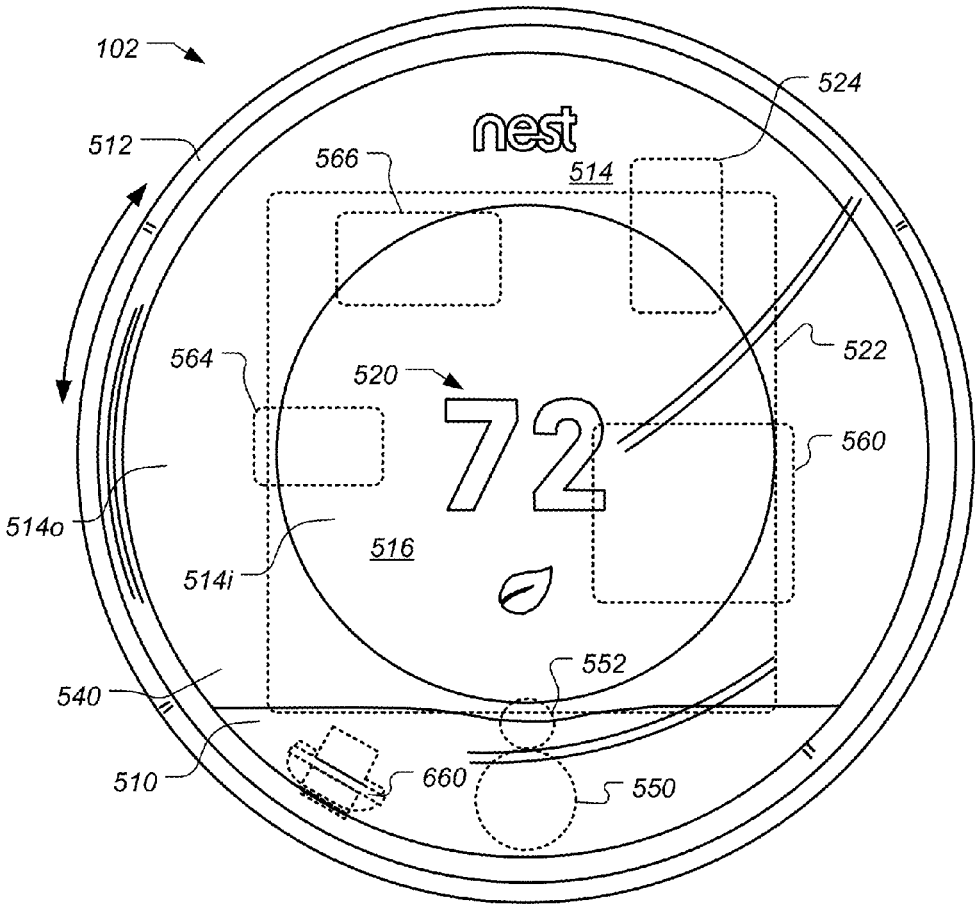
446
436

FIG. 4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nest
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72
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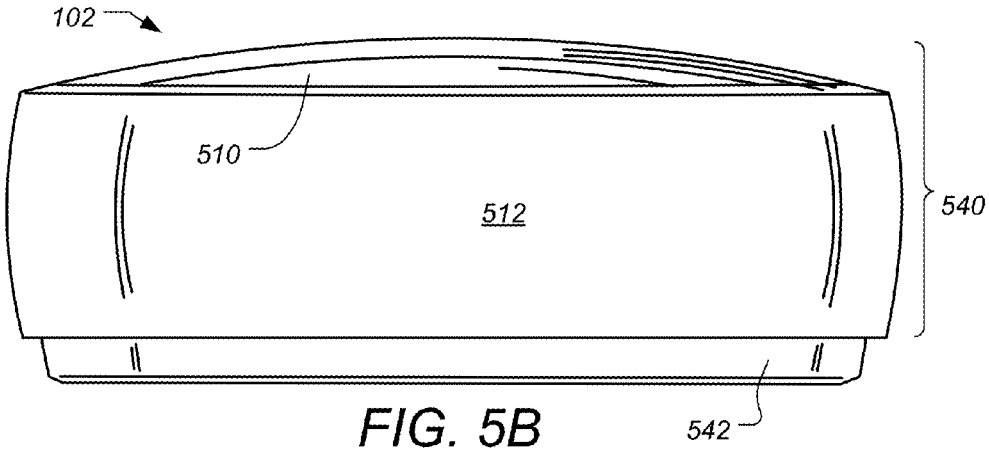
514o
516
514i
552
540
510
660
550

FIG. 5A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540
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FIG. 5B

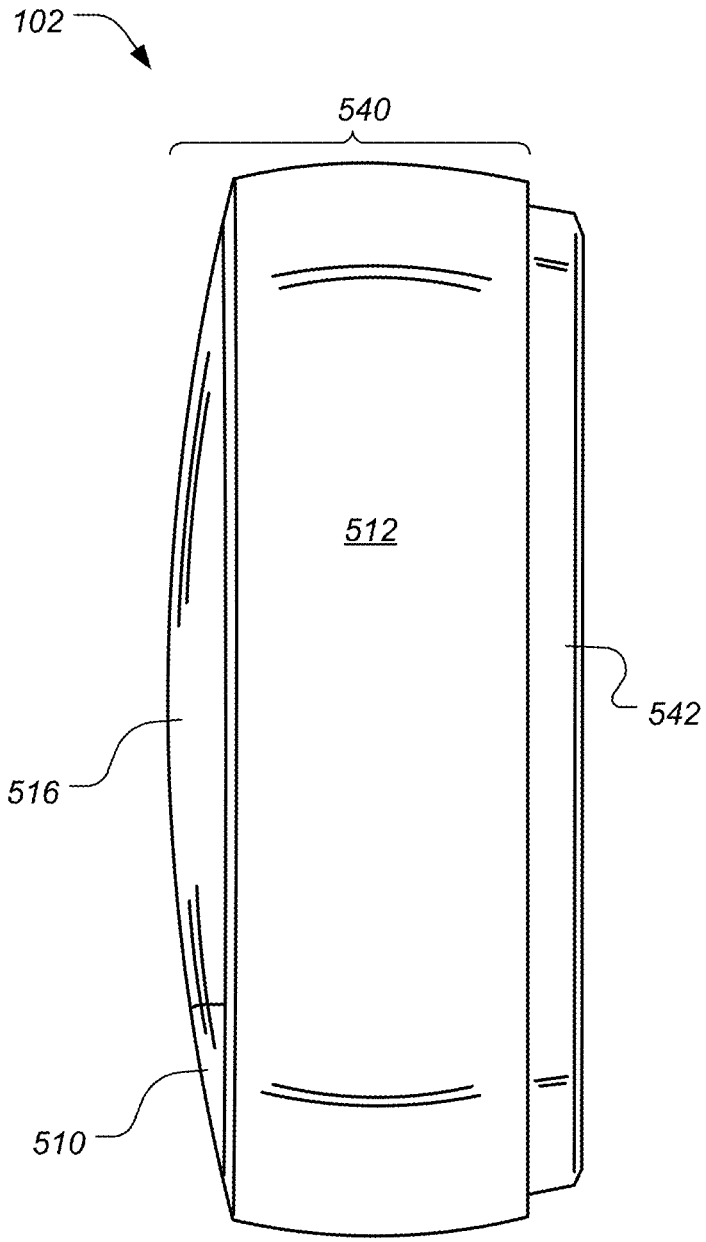


FIG. 5C

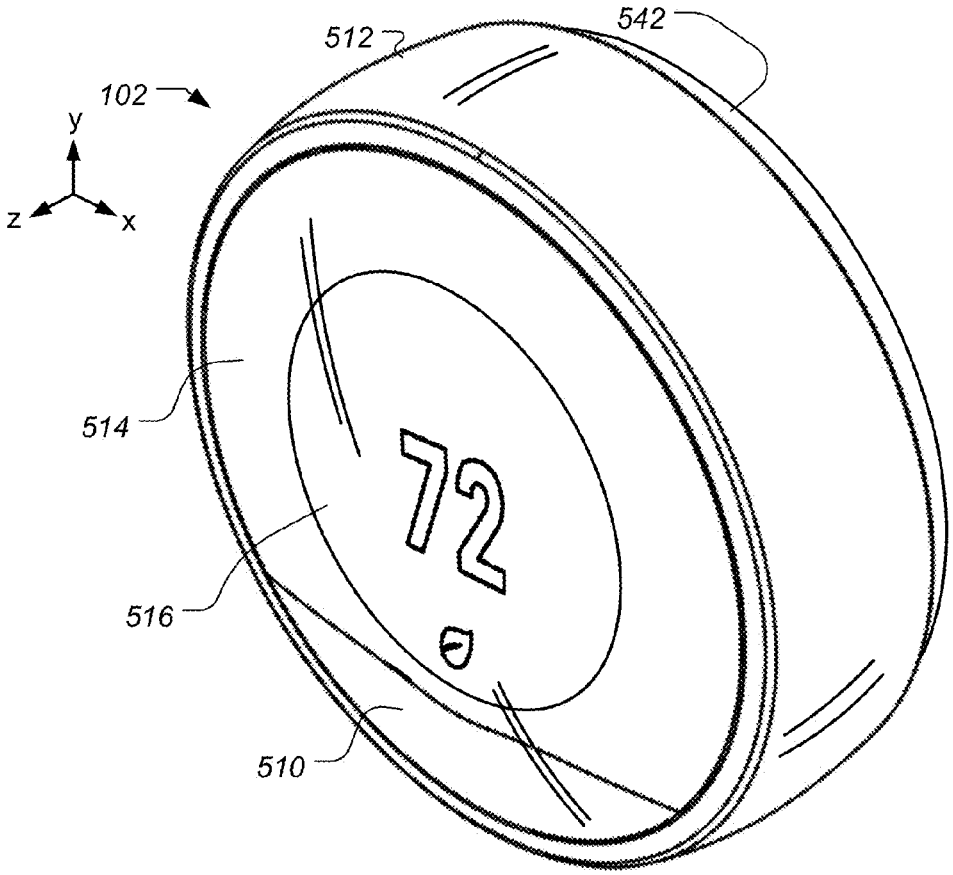


FIG. 5D

FIG. 6A

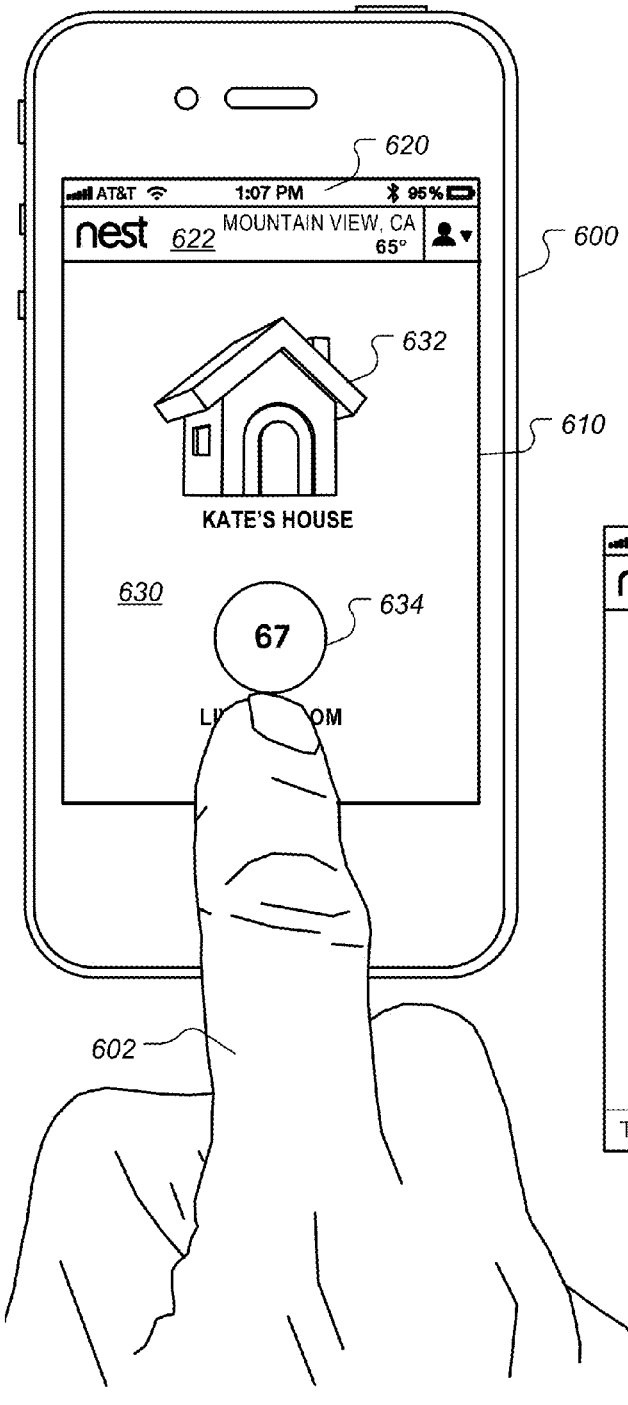
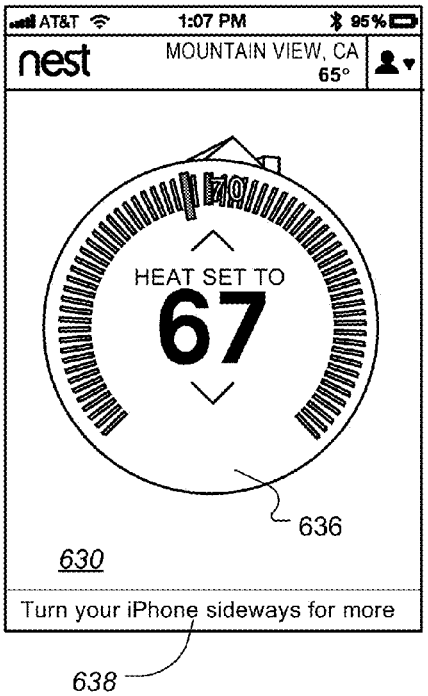

620
AT&T
1:07 PM
95%
nest
622
MOUNTAIN VIEW, CA
65°
600
632
610
KATE'S HOUSE
630
67
634
602

FIG. 6B


AT&T
1:07 PM
95%
nest
MOUNTAIN VIEW, CA
65°
HEAT SET TO
67
636
630
Turn your iPhone sideways for more
638

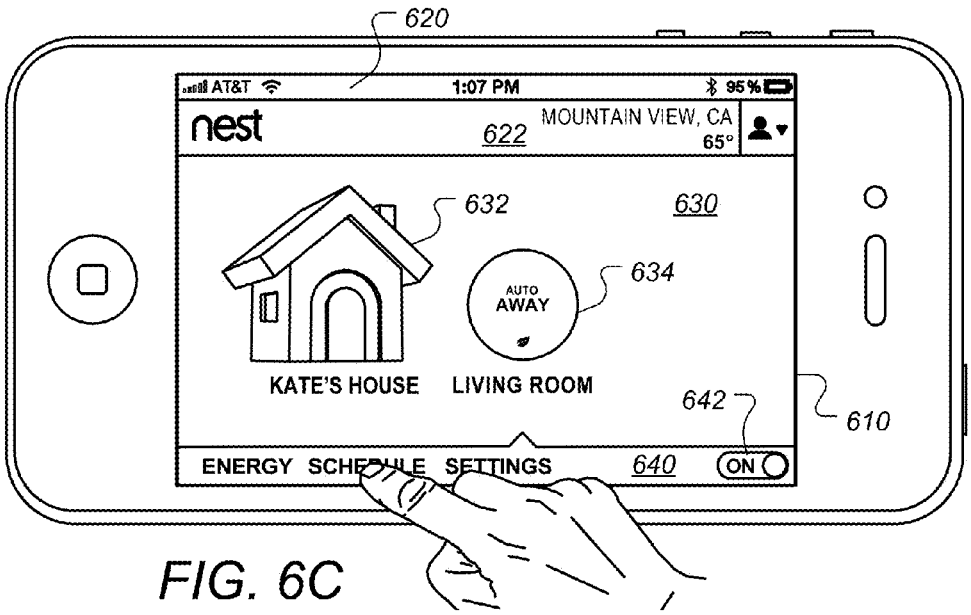

620
AT&T
1:07 PM
95%
nest
622
MOUNTAIN VIEW, CA
65°
632
630
634
AUTO
AWAY
KATE'S HOUSE
LIVING ROOM
642
610
ENERGY SCHEDULE SETTINGS
640
ON

FIG. 6C

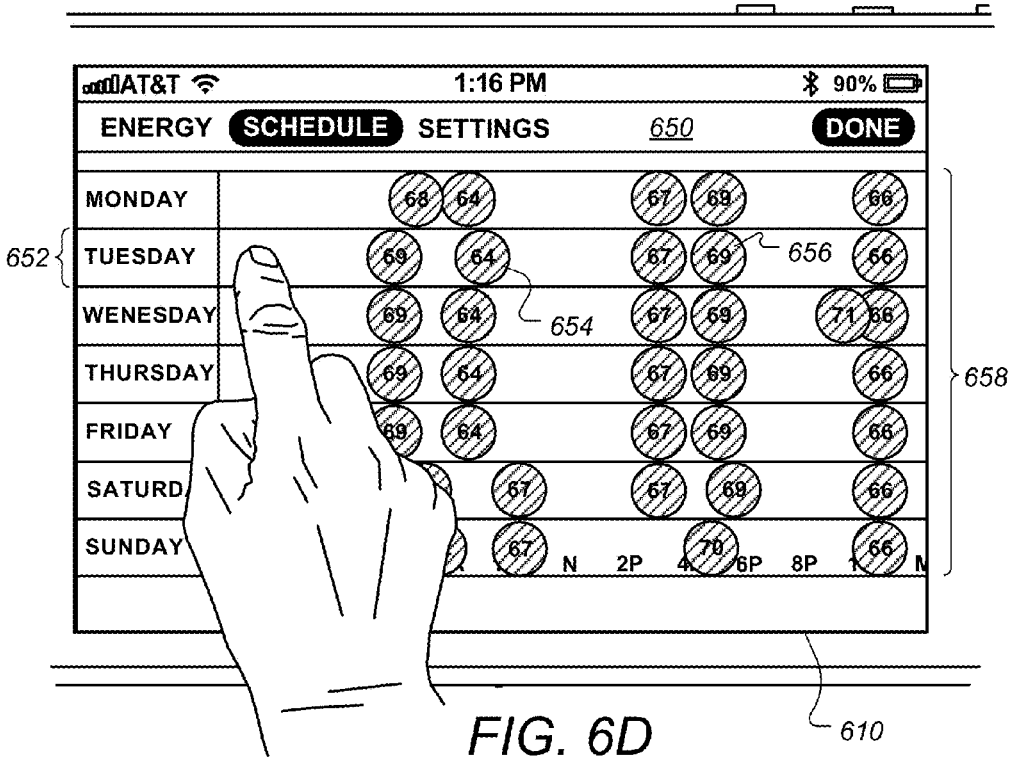
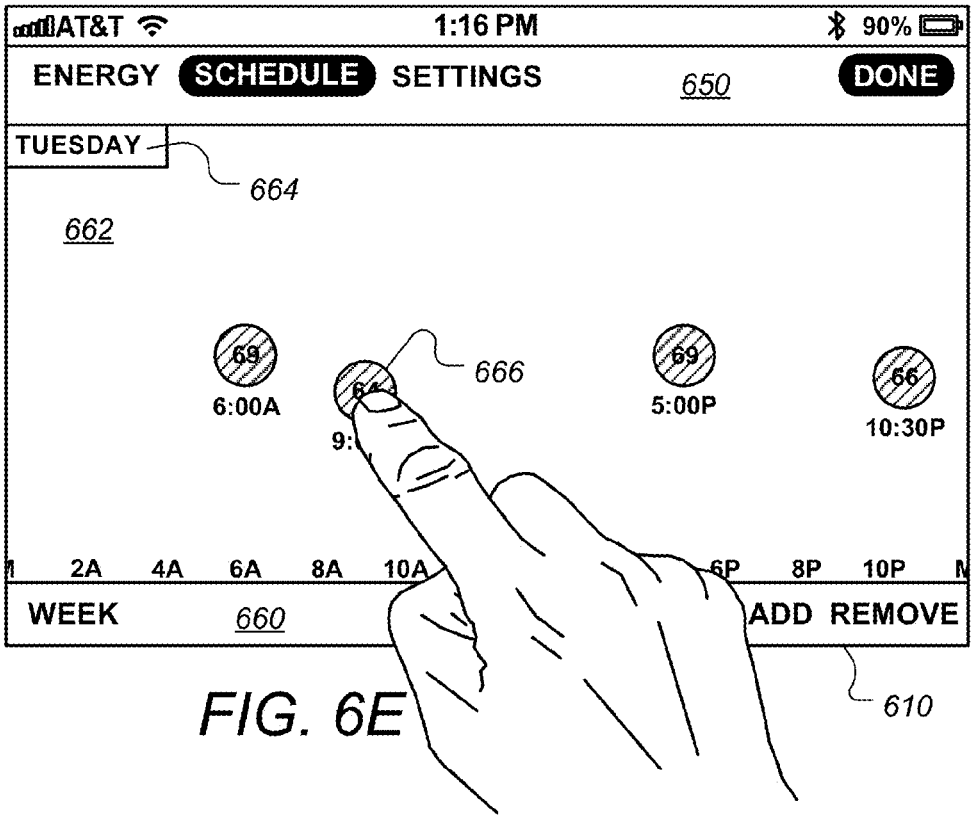

AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
MONDAY
TUESDAY
WENESDAY
THURSDAY
FRIDAY
SATURD
SUNDAY
652
656
654
658
610
N
2P
6P
8P

FIG. 6D


AT&T
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ENERGY
SCHEDULE
SETTINGS
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DONE
TUESDAY
664
662
69
6:00A
666
69
5:00P
66
10:30P
2A
4A
6A
8A
10A
6P
8P
10P
WEEK
660
ADD
REMOVE
610

FIG. 6E

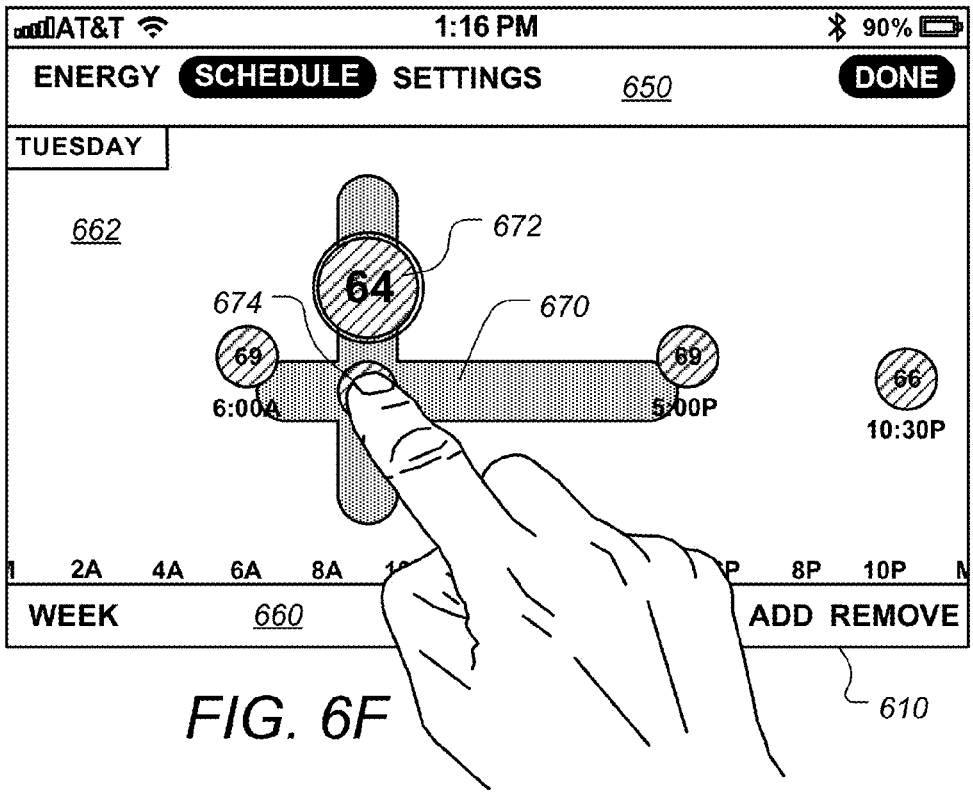
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
TUESDAY
662
672
64
674
670
69
6:00A
69
5:00P
66
10:30P
2A
4A
6A
8A
8P
10P
WEEK
660
ADD
REMOVE
610

FIG. 6F

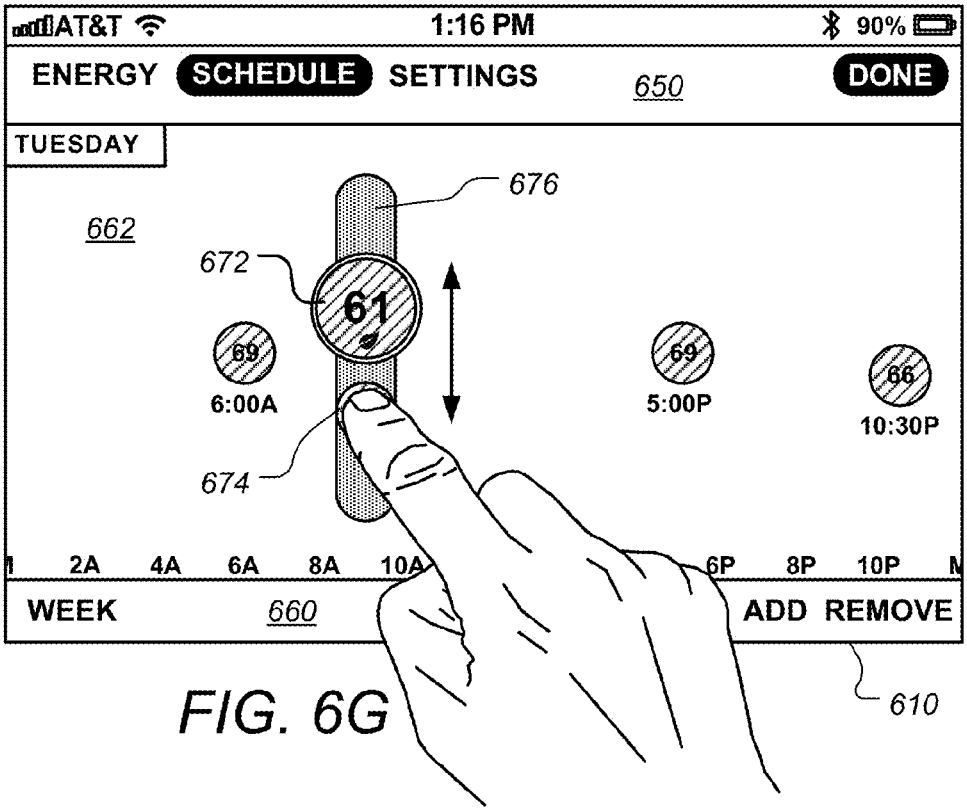
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
TUESDAY
662
676
672
61
69
6:00A
69
5:00P
66
10:30P
674
1
2A
4A
6A
8A
10A
6P
8P
10P
WEEK
660
ADD
REMOVE
610

FIG. 6G

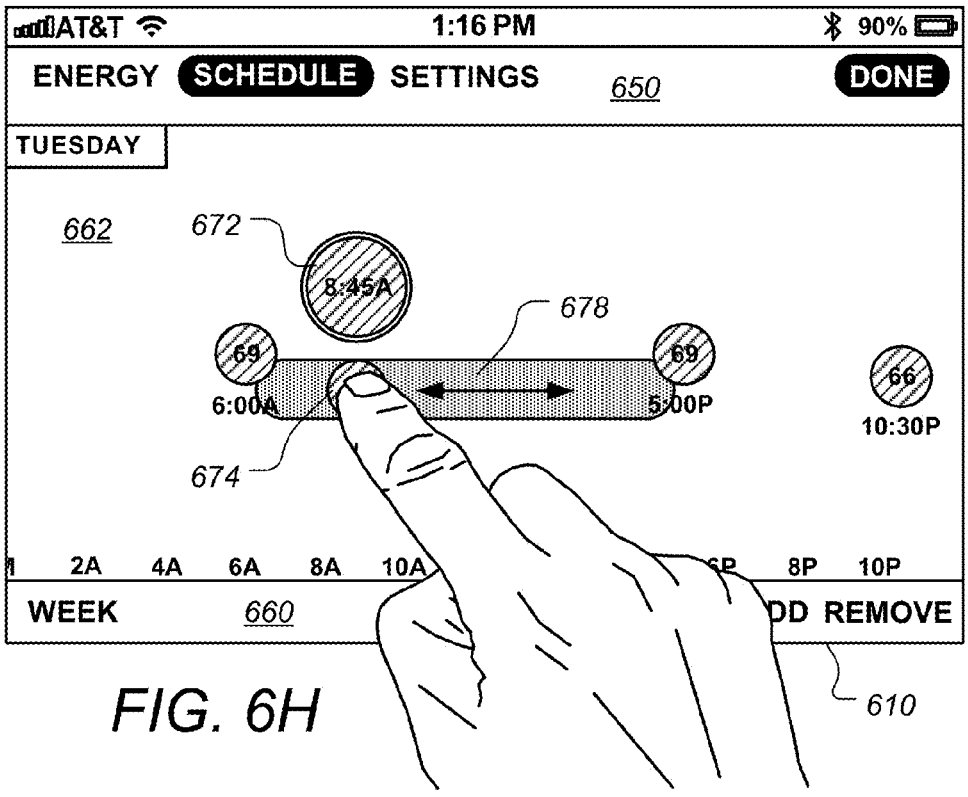
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
TUESDAY
662
672
8:45A
678
69
6:00A
69
5:00P
66
10:30P
674
1
2A
4A
6A
8A
10A
8P
10P
WEEK
660
610

FIG. 6H

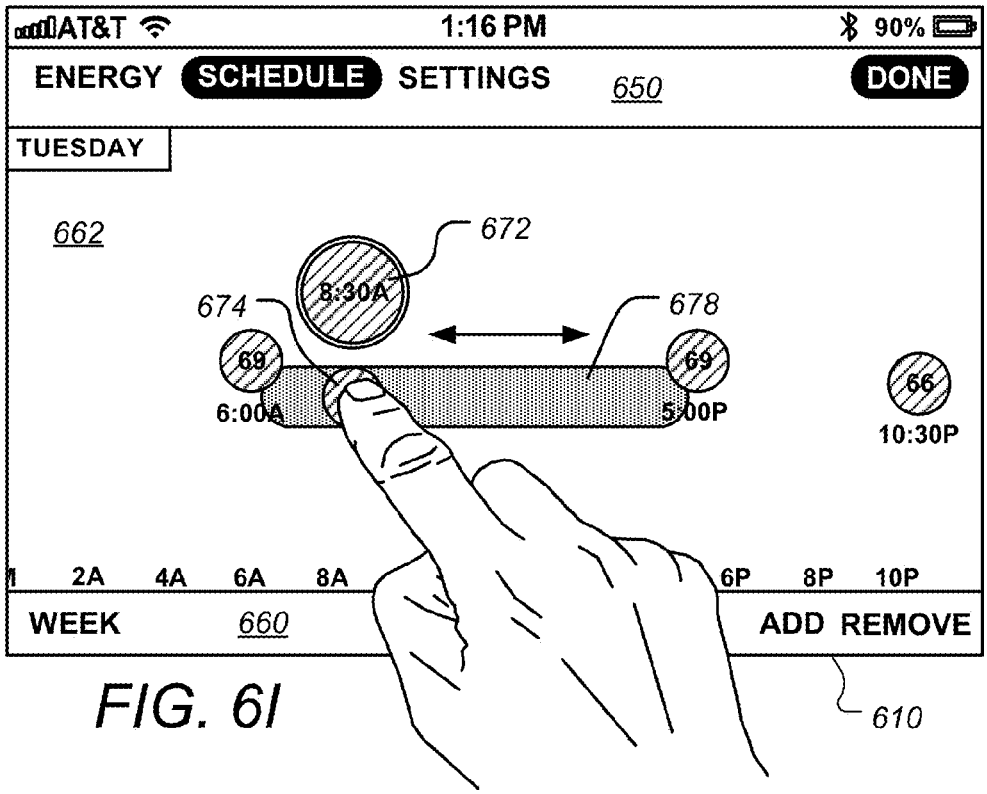
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
TUESDAY
662
672
8:30A
674
678
69
69
6:00A
5:00P
66
10:30P
1
2A
4A
6A
8A
6P
8P
10P
WEEK
660
ADD REMOVE
610

FIG. 6I

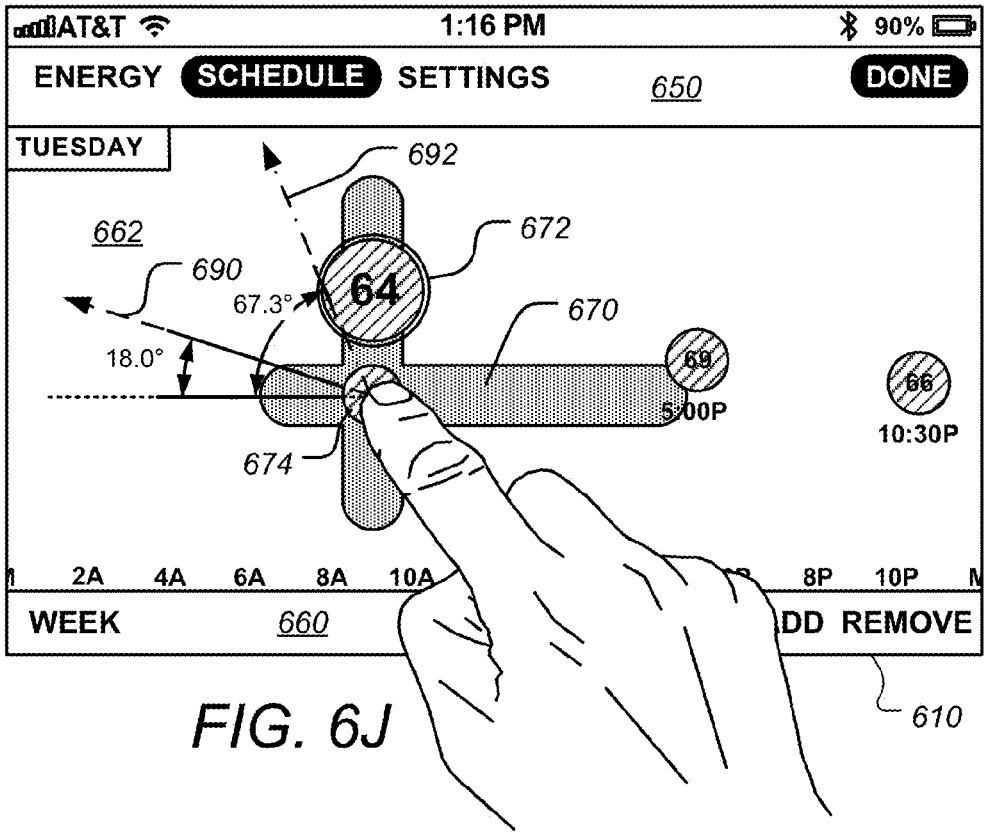
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
TUESDAY
692
662
672
690
64
67.3°
670
18.0°
69
5:00P
66
10:30P
674
1
2A
4A
6A
8A
10A
8P
10P
WEEK
660
DD REMOVE
610

FIG. 6J

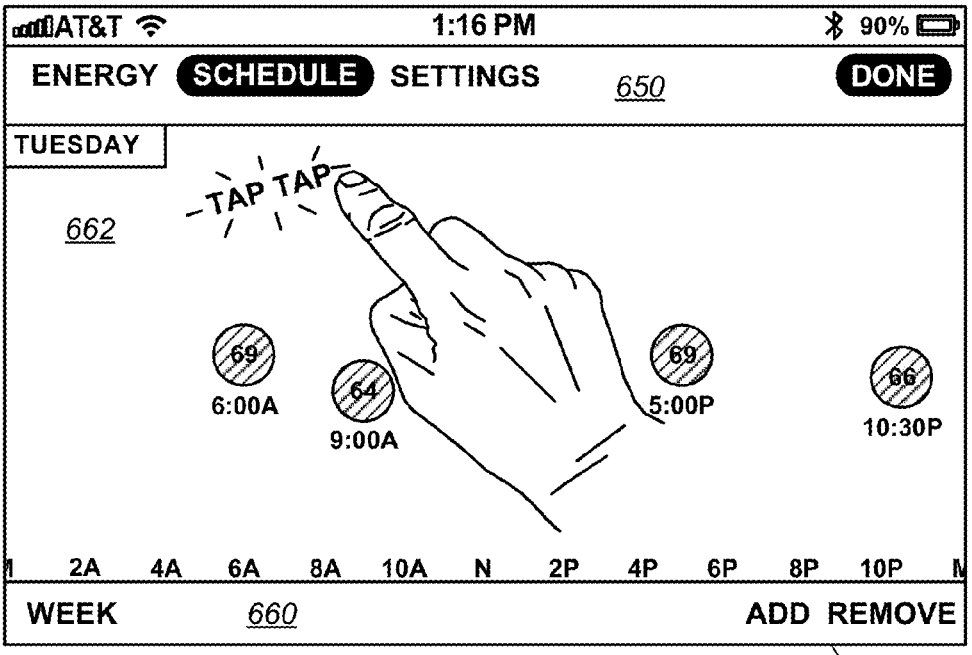
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
TUESDAY
662
TAP TAP
69
6:00A
64
9:00A
69
5:00P
66
10:30P
1
2A
4A
6A
8A
10A
N
2P
4P
6P
8P
10P
M
WEEK
660
ADD
REMOVE
610

FIG. 6K

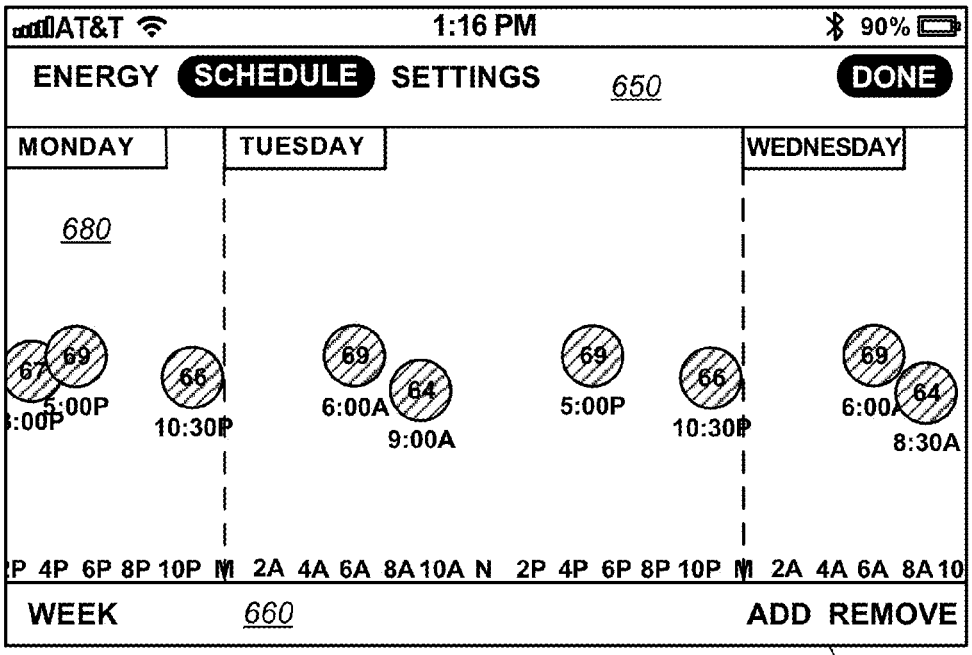
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
MONDAY
TUESDAY
WEDNESDAY
680
67
69
5:00P
66
10:30P
69
6:00A
64
9:00A
69
5:00P
66
10:30P
69
6:00A
64
8:30A
WEEK
660
ADD
REMOVE
610

FIG. 6L

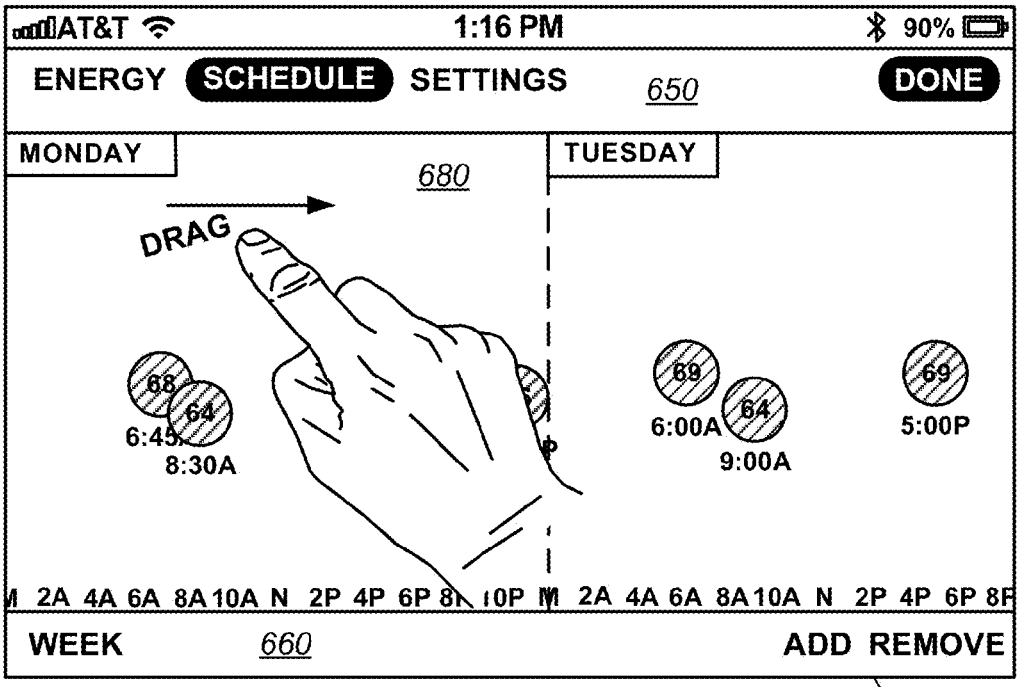
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
MONDAY
TUESDAY
680
DRAG
68
64
6:45
8:30A
69
64
6:00A
9:00A
69
5:00P
2A 4A 6A 8A 10A N 2P 4P 6P 8P 10P M 2A 4A 6A 8A 10A N 2P 4P 6P 8P
WEEK
660
ADD REMOVE
610

FIG. 6M

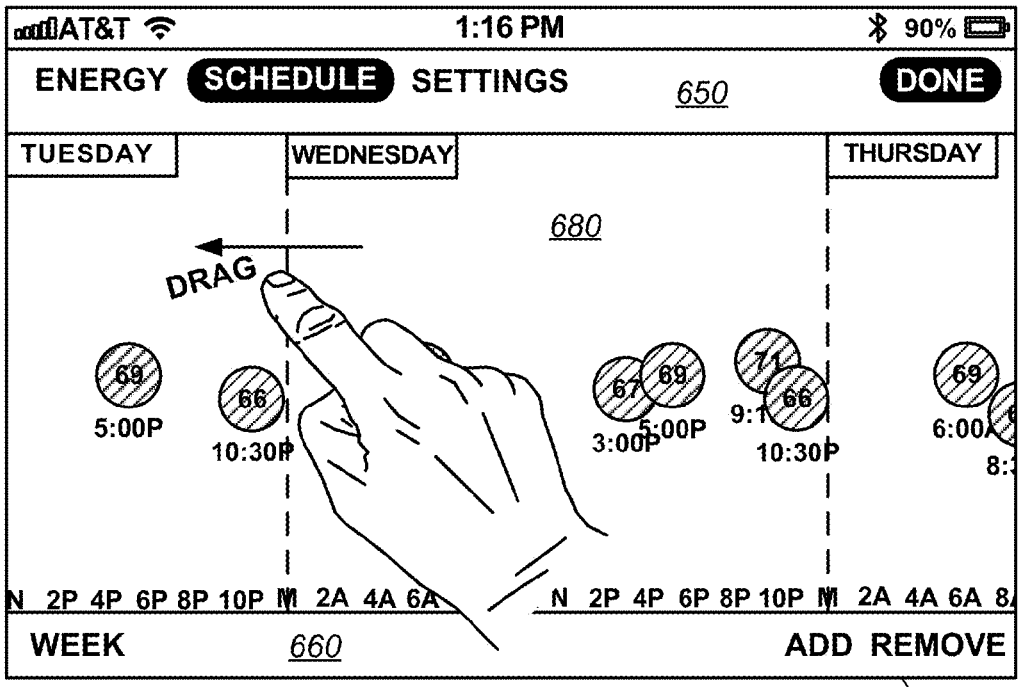
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
TUESDAY
WEDNESDAY
THURSDAY
680
DRAG
69
5:00P
66
10:30P
67
69
3:00P
5:00P
71
66
9:1
10:30P
69
6:00A
N 2P 4P 6P 8P 10P M 2A 4A 6A
N 2P 4P 6P 8P 10P M 2A 4A 6A
WEEK
660
ADD REMOVE
610

FIG. 6N

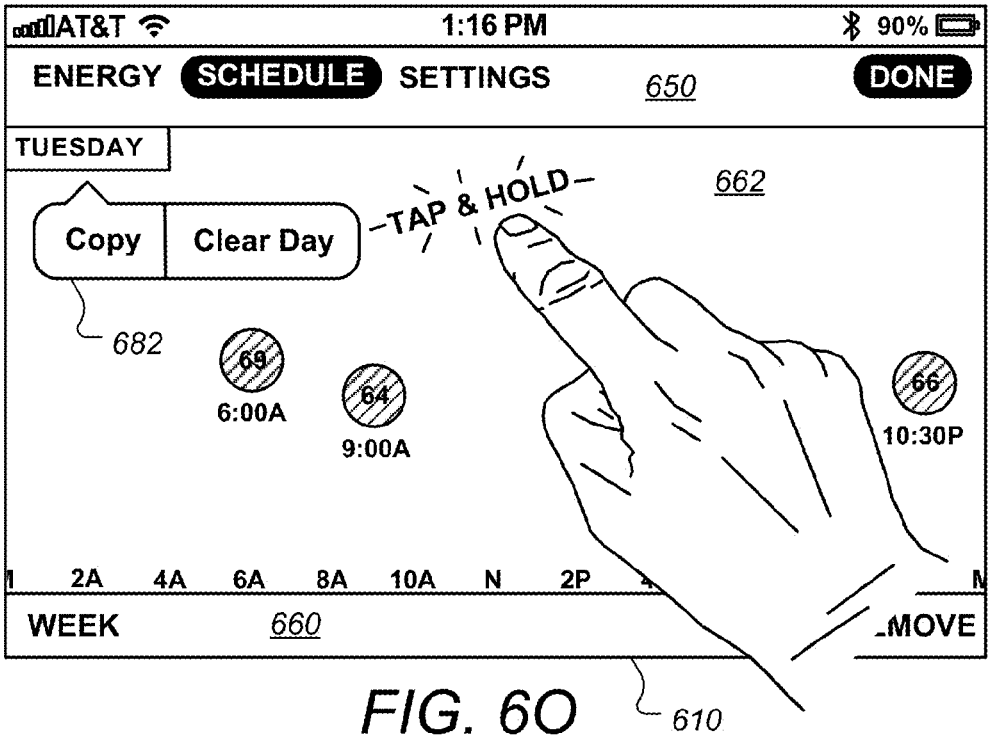
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
TUESDAY
Copy
Clear Day
TAP & HOLD
662
682
69
6:00A
64
9:00A
66
10:30P
2A
4A
6A
8A
10A
N
2P
WEEK
660
MOVE
610

FIG. 6O

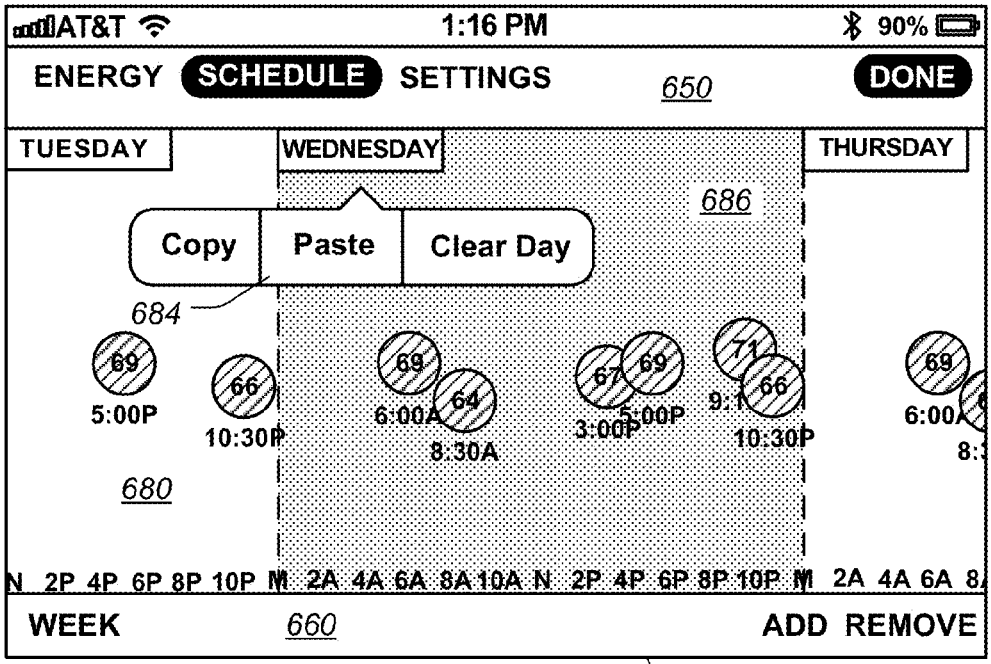
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
TUESDAY
WEDNESDAY
THURSDAY
686
Copy
Paste
Clear Day
684
69
5:00P
66
10:30P
69
6:00A
64
8:30A
67
3:00P
69
5:00P
71
66
10:30P
69
680
N 2P 4P 6P 8P 10P M 2A 4A 6A 8A 10A N 2P 4P 6P 8P 10P M 2A 4A 6A
WEEK
660
ADD REMOVE
610

FIG. 6P

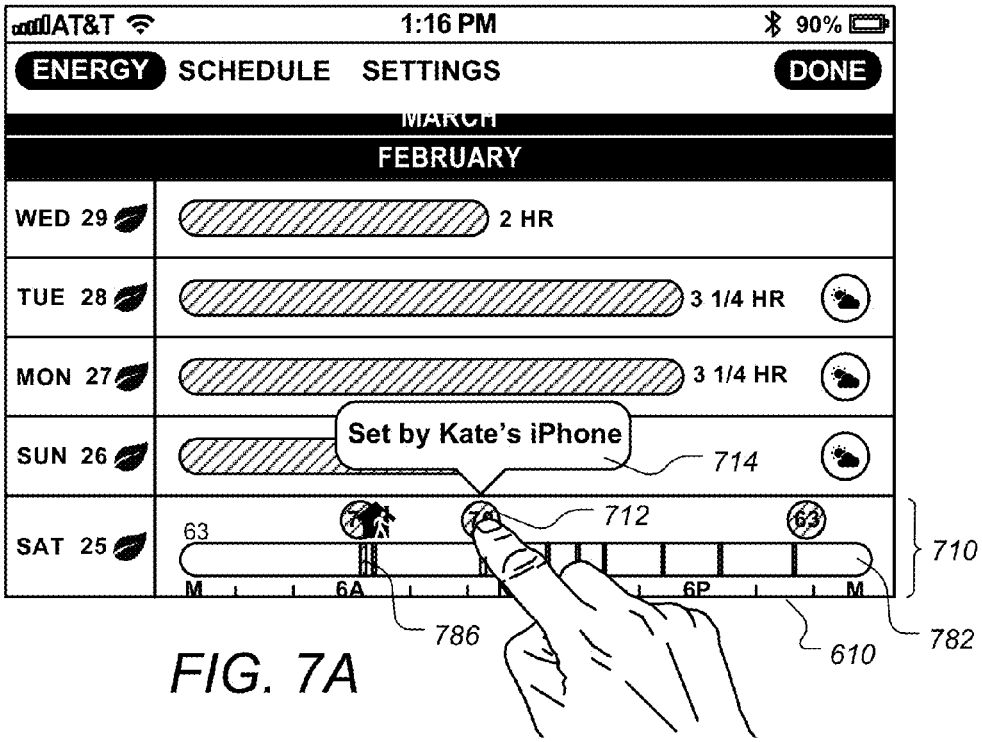
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
DONE
MARCH
FEBRUARY
WED 29
2 HR
TUE 28
3 1/4 HR
MON 27
3 1/4 HR
SUN 26
SAT 25
Set by Kate's iPhone
714
712
710
63
M
6A
6P
M
786
610
782

FIG. 7A

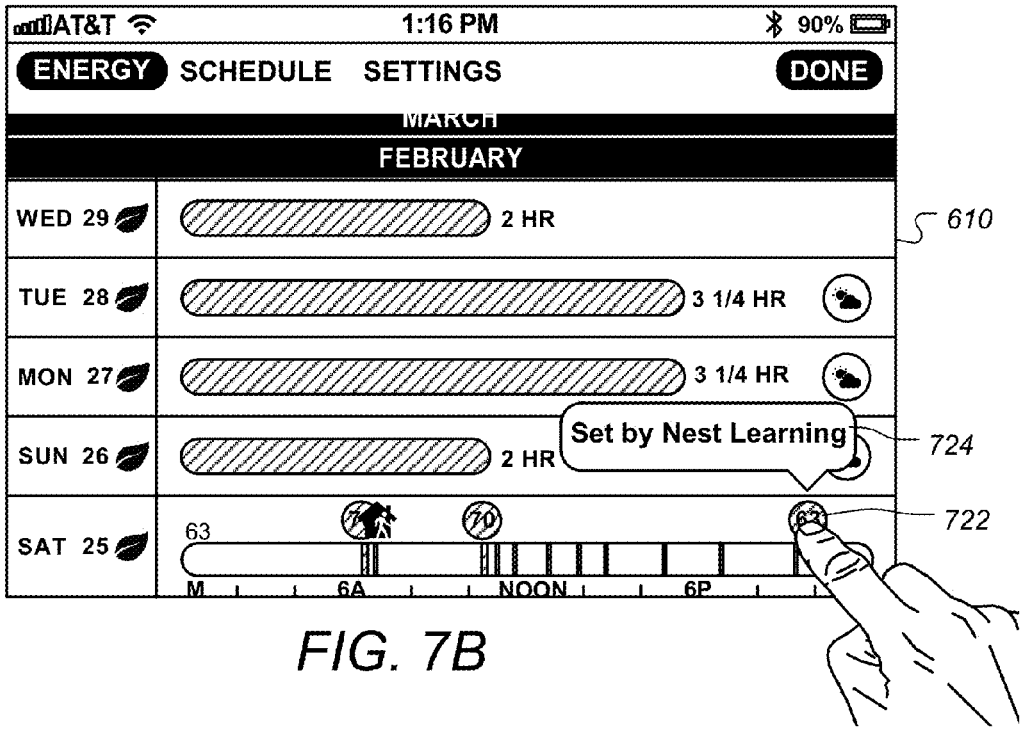
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
DONE
MARCH
FEBRUARY
WED 29
2 HR
610
TUE 28
3 1/4 HR
MON 27
3 1/4 HR
SUN 26
2 HR
Set by Nest Learning
724
SAT 25
63
70
722
M
6A
NOON
6P

FIG. 7B

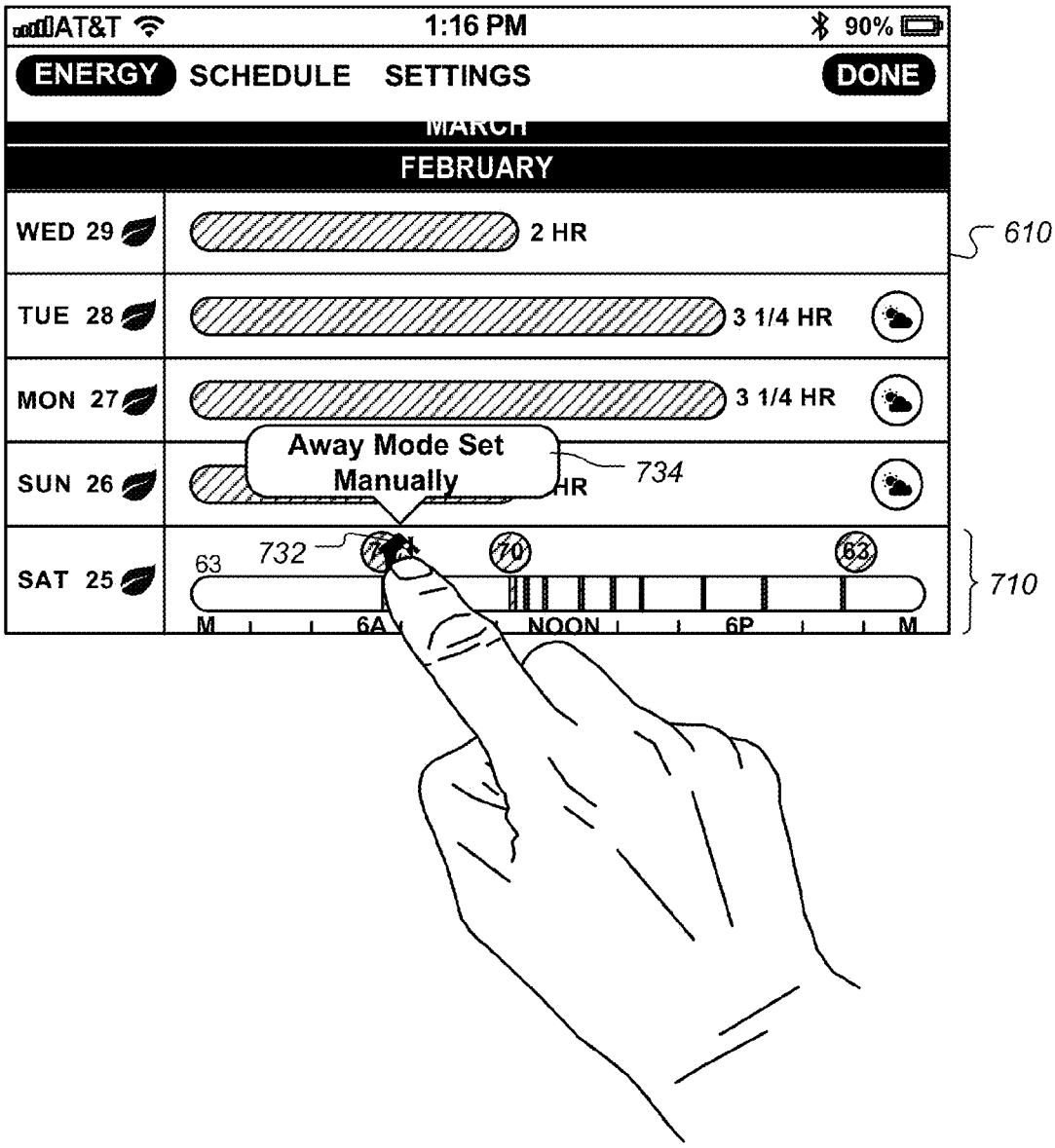
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
DONE
MARCH
FEBRUARY
WED 29
2 HR
610
TUE 28
3 1/4 HR
MON 27
3 1/4 HR
Away Mode Set Manually
734
SUN 26
HR
SAT 25
732
63
70
63
710
M
6A
NOON
6P
M

FIG. 7C

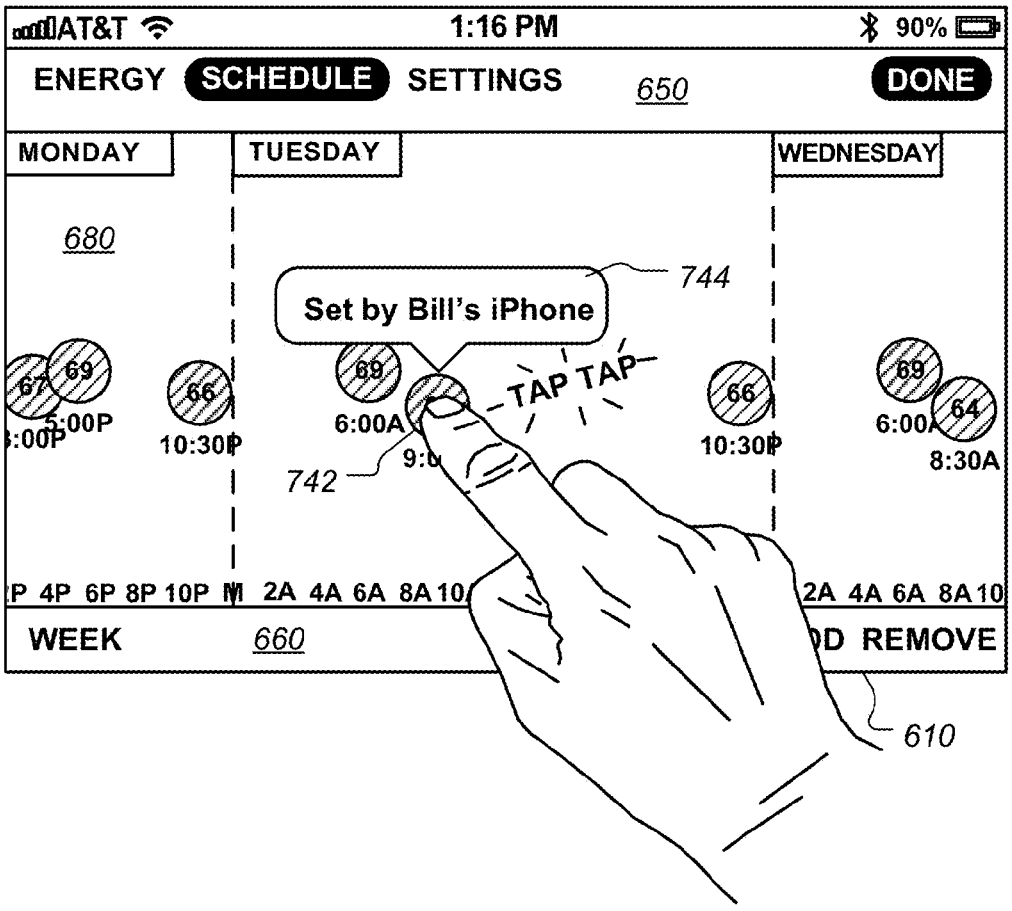
AT&T
1:16 PM
90%
ENERGY
SCHEDULE
SETTINGS
650
DONE
MONDAY
TUESDAY
WEDNESDAY
680
744
Set by Bill's iPhone
TAP TAP
67
69
5:00P
66
10:30P
69
6:00A
742
66
10:30P
69
6:00A
64
8:30A
2A 4A 6A 8A 10
2A 4A 6A 8A 10
WEEK
660
REMOVE
610

FIG. 7D

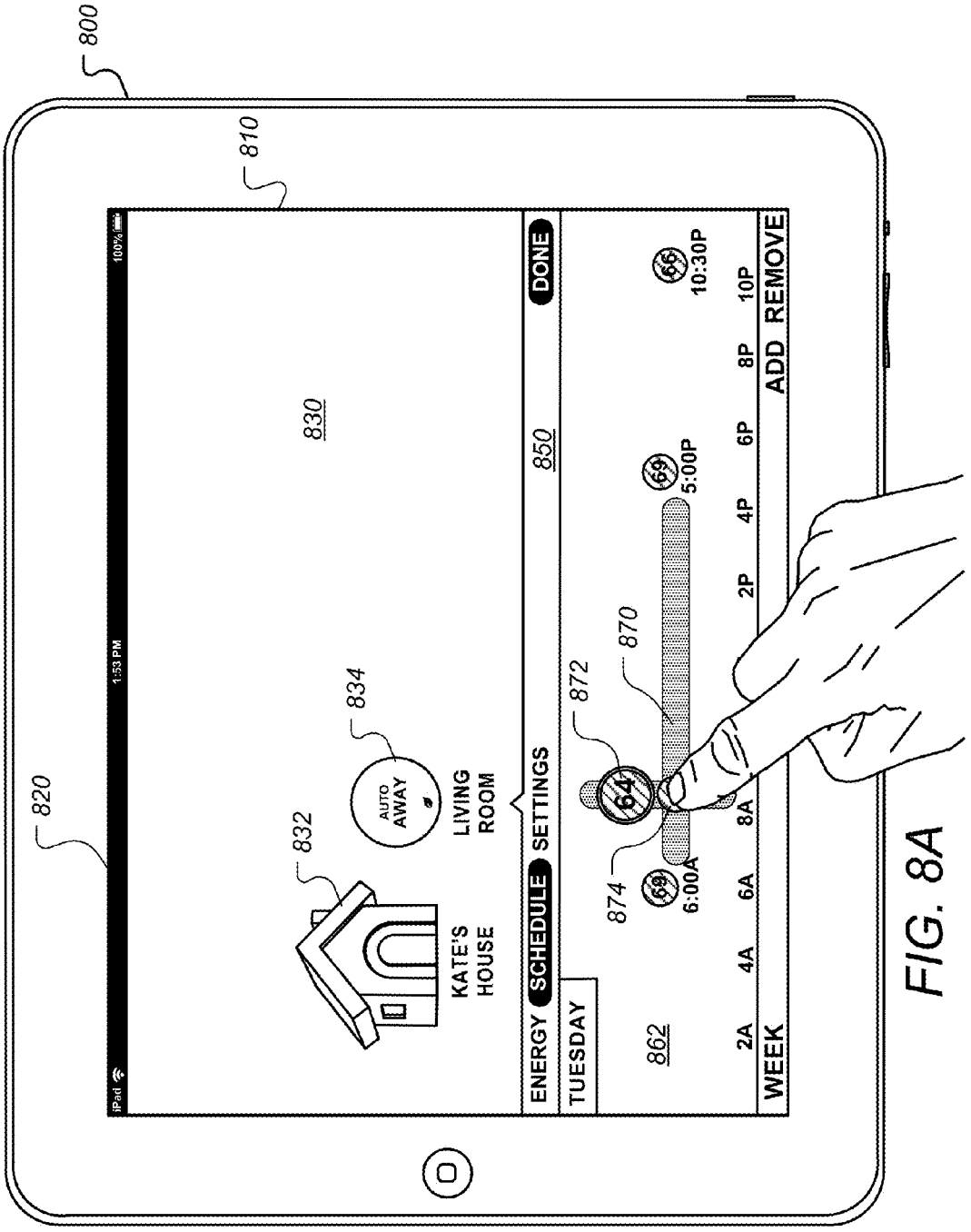
800
810
820
830
832
834
AUTO AWAY
LIVING ROOM
KATE'S HOUSE
ENERGY
SCHEDULE
SETTINGS
DONE
850
872
870
874
862
TUESDAY
WEEK
ADD
REMOVE
6:00A
5:00P
10:30P
2A
4A
6A
8A
2P
4P
6P
8P
10P
64
69
66
1:53 PM
100%
iPad

FIG. 8A

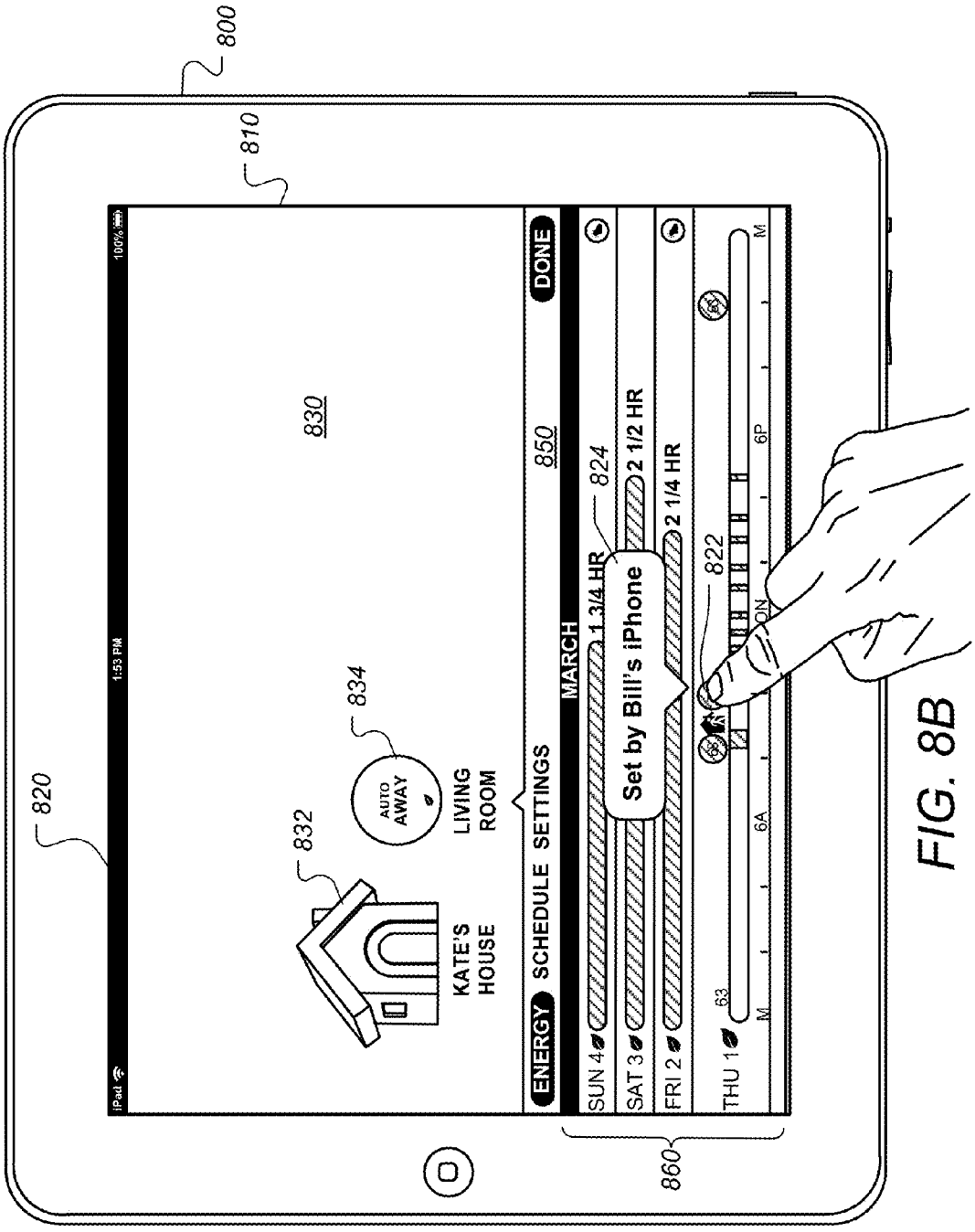
800
810
820
830
832
834
KATE'S HOUSE
AUTO AWAY
LIVING ROOM
ENERGY
SCHEDULE
SETTINGS
DONE
850
MARCH
SUN 4
SAT 3
FRI 2
THU 1
1 3/4 HR
2 1/2 HR
2 1/4 HR
824
822
Set by Bill's iPhone
860
6A
6P
ON

FIG. 8B

USER INTERFACES FOR HVAC SCHEDULE DISPLAY AND MODIFICATION ON SMARTPHONE OR OTHER SPACE-LIMITED TOUCHSCREEN DEVICE

This application is a continuation of U.S. Ser. No. 13/624,875, filed Sep. 21, 2012, which is a continuation-in-part of U.S. Ser. No. 13/434,560 filed Mar. 29, 2012. Each of the above-referenced patent applications is incorporated by reference herein.

FIELD

This patent specification relates to systems, methods, and related computer program products for the monitoring and control of energy-consuming systems or other resource-consuming systems. More particularly, this patent specification relates to user interfaces for HVAC schedule display and modification on smartphone or other space-limited touchscreen device.

BACKGROUND

Particular challenges arise when designing a remote user-interface for a programmable thermostat where the remote user device is a smart phone or other space-limited touch screen device. On such space limited devices it can be difficult or confusing for a user to make simple programming changes such as adding, editing or deleting setpoints, as well as obtain information with would be useful in maintaining both comfort in the user's dwelling and energy efficiency of the HVAC system.

It is to be appreciated that although exemplary embodiments are presented herein for the particular context of HVAC system control, there are a wide variety of other resource usage contexts for which the embodiments are readily applicable including, but not limited to, water usage, air usage, the usage of other natural resources, and the usage of other (i.e., non-HVAC-related) forms of energy, as would be apparent to the skilled artisan in view of the present disclosure. Therefore, such application of the embodiments in such other resource usage contexts is not outside the scope of the present teachings.

SUMMARY

According to one or more embodiments, a method is described of interactively and graphically interfacing with a user of an HVAC system controlled by a thermostat. The method includes: storing a plurality of programmed setpoints on a memory on the thermostat, each of the setpoints being associated with a setpoint temperature and a time at which the setpoint is programmed to become active; on a small format touch-screen display device in a location remote from the thermostat (for example on a smart phone or a table computer), graphically displaying a two dimensional plot including one or more setpoint icons each being associated with one of the plurality of programmed setpoints, such that the position of each setpoint icon indicates to the user the temperature by virtue of a position of the icon along a first axis and the time by virtue of a position of the icon along a second axis associated with the associated setpoint; receiving user input in a form of a touch motion (for example a dragging motion) by the user of a displayed setpoint icon indicating an intention by the user to adjust (1) the temperature of the setpoint associated with the icon by virtue of the touch motion being primarily in a direction parallel to the first axis, or (2) the time of the setpoint associated with the icon by virtue of the touch motion being primarily in the direction of the second axis; and constraining user adjustments to time adjustments when the received user input indicates an intention to adjust the time, and constraining user adjustments to temperature adjustments when the received user input indicates an intention to adjust the temperature.

According to some embodiments indicators (such as shaded bars) are displayed indicating that the setpoint can be adjusted both in directions initially (parallel to both the first and second axes), and after the constraining, displaying only indicators associated with the un-constrained axis. According to some embodiments, a large setpoint icon can be displayed above the setpoint icon.

According to some embodiments, a method is described of interactively and graphically displaying programmed setpoint information to a user of an HVAC system controlled by a thermostat. The method includes: receiving and storing information indicating for a first thermostat setpoint, a way in which the first setpoint was generated and/or adjusted, the indicated way being selected from one of a plurality of predefined ways in which setpoints can be generated and/or adjusted; on a display device in a location remote from the thermostat, graphically displaying a graphical daily summary of thermostat information for each of a plurality of days, the graphical daily summary including at least a first setpoint icon representing the first setpoint; and in response to a user selecting of a displayed first setpoint icon, displaying information indicating to the user the way in which the first setpoint was generated and/or adjusted. According to some embodiments the plurality of predefined ways includes one or more of the following: by a user on the thermostat, by a user using a mobile device, by a user using a web application, and by an automated learning algorithm. When the setpoint was generated and/or adjusted by a mobile device, the displayed information preferably indicates an identification of a name associated with a mobile device.

It will be appreciated that these systems and methods are novel, as are applications thereof and many of the components, systems, methods and algorithms employed and included therein. It should be appreciated that embodiments of the presently described inventive body of work can be implemented in numerous ways, including as processes, apparata, systems, devices, methods, computer readable media, computational algorithms, embedded or distributed software and/or as a combination thereof. Several illustrative embodiments are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

The inventive body of work will be readily understood by referring to the following detailed description in conjunction with the accompanying drawings, in which:

FIG. **1** illustrates an example of a smart home environment within which one or more of the devices, methods, systems, services, and/or computer program products described further herein can be applicable;

FIG. **2** illustrates a network-level view of an extensible devices and services platform with which the smart home of FIG. **1** can be integrated, according to some embodiments;

FIG. **3** illustrates an abstracted functional view of the extensible devices and services platform of FIG. **2**, according to some embodiments;

FIG. **4** is a schematic diagram of an HVAC system, according to some embodiments;

FIGS. **5**A-**5**D illustrate a thermostat having a visually pleasing, smooth, sleek and rounded exterior appearance while at the same time including one or more sensors for detecting occupancy and/or users, according to some embodiments;

FIGS. **6**A-**6**P illustrate aspects of a graphical user interface on small format touch-screen device for a network connected programmable thermostat, according to some embodiments;

FIGS. **7**A-**7**D show aspects of a thermostat graphical user interface implemented on a small-format touch screen device pertaining to responsibility for setpoint changes and other events, according to some embodiments; and

FIGS. **8**A-**8**B show aspects of a thermostat graphical user interface implemented on a tablet computer with a touch screen device, according to some embodiments.

DETAILED DESCRIPTION

The subject matter of this patent specification relates to the subject matter of the following commonly assigned applications, each of which is incorporated by reference herein: U.S. Ser. No. 13/269,501 filed Oct. 7, 2011; and U.S. Ser. No. 13/317,423 filed Oct. 17, 2011. The above-referenced patent applications are collectively referenced herein as "the commonly assigned incorporated applications."

A detailed description of the inventive body of work is provided herein. While several embodiments are described, it should be understood that the inventive body of work is not limited to any one embodiment, but instead encompasses numerous alternatives, modifications, and equivalents. In addition, while numerous specific details are set forth in the following description in order to provide a thorough understanding of the inventive body of work, some embodiments can be practiced without some or all of these details. Moreover, for the purpose of clarity, certain technical material that is known in the related art has not been described in detail in order to avoid unnecessarily obscuring the inventive body of work.

As used herein the term "HVAC" includes systems providing both heating and cooling, heating only, cooling only, as well as systems that provide other occupant comfort and/or conditioning functionality such as humidification, dehumidification and ventilation.

As used herein the terms power "harvesting," "sharing" and "stealing" when referring to HVAC thermostats all refer to thermostats that are designed to derive power from the power transformer through the equipment load without using a direct or common wire source directly from the transformer.

As used herein the term "residential" when referring to an HVAC system means a type of HVAC system that is suitable to heat, cool and/or otherwise condition the interior of a building that is primarily used as a single family dwelling. An example of a cooling system that would be considered residential would have a cooling capacity of less than about 5 tons of refrigeration (1 ton of refrigeration=12,000 Btu/h).

As used herein the term "light commercial" when referring to an HVAC system means a type of HVAC system that is suitable to heat, cool and/or otherwise condition the interior of a building that is primarily used for commercial purposes, but is of a size and construction that a residential HVAC system is considered suitable. An example of a cooling system that would be considered residential would have a cooling capacity of less than about 5 tons of refrigeration.

As used herein the term "thermostat" means a device or system for regulating parameters such as temperature and/or humidity within at least a part of an enclosure. The term "thermostat" may include a control unit for a heating and/or cooling system or a component part of a heater or air conditioner. As used herein the term "thermostat" can also refer generally to a versatile sensing and control unit (VSCU unit) that is configured and adapted to provide sophisticated, customized, energy-saving HVAC control functionality while at the same time being visually appealing, non-intimidating, elegant to behold, and delightfully easy to use.

FIG. **1** illustrates an example of a smart home environment within which one or more of the devices, methods, systems, services, and/or computer program products described further herein can be applicable. The depicted smart home environment includes a structure **150**, which can include, e.g., a house, office building, garage, or mobile home. It will be appreciated that devices can also be integrated into a smart home environment that does not include an entire structure **150**, such as an apartment, condominium, or office space. Further, the smart home environment can control and/or be coupled to devices outside of the actual structure **150**. Indeed, several devices in the smart home environment need not physically be within the structure **150** at all. For example, a device controlling a pool heater or irrigation system can be located outside of the structure **150**.

The depicted structure **150** includes a plurality of rooms **152**, separated at least partly from each other via walls **154**. The walls **154** can include interior walls or exterior walls. Each room can further include a floor **156** and a ceiling **158**. Devices can be mounted on, integrated with and/or supported by a wall **154**, floor or ceiling.

The smart home depicted in FIG. **1** includes a plurality of devices, including intelligent, multi-sensing, network-connected devices that can integrate seamlessly with each other and/or with cloud-based server systems to provide any of a variety of useful smart home objectives. One, more or each of the devices illustrated in the smart home environment and/or in the figure can include one or more sensors, a user interface, a power supply, a communications component, a modularity unit and intelligent software as described herein. Examples of devices are shown in FIG. **1**.

An intelligent, multi-sensing, network-connected thermostat **102** can detect ambient climate characteristics (e.g., temperature and/or humidity) and control a heating, ventilation and air-conditioning (HVAC) system **103**. One or more intelligent, network-connected, multi-sensing hazard detection units **104** can detect the presence of a hazardous substance and/or a hazardous condition in the home environment (e.g., smoke, fire, or carbon monoxide). One or more intelligent, multi-sensing, network-connected entryway interface devices **106**, which can be termed a "smart doorbell", can detect a person's approach to or departure from a location, control audible functionality, announce a person's approach or departure via audio or visual means, or control settings on a security system (e.g., to activate or deactivate the security system).

Each of a plurality of intelligent, multi-sensing, network-connected wall light switches **108** can detect ambient lighting conditions, detect room-occupancy states and control a power and/or dim state of one or more lights. In some instances, light switches **108** can further or alternatively control a power state or speed of a fan, such as a ceiling fan. Each of a plurality of intelligent, multi-sensing, network-connected wall plug interfaces **110** can detect occupancy of a room or enclosure and control supply of power to one or

more wall plugs (e.g., such that power is not supplied to the plug if nobody is at home). The smart home may further include a plurality of intelligent, multi-sensing, network-connected appliances **112**, such as refrigerators, stoves and/or ovens, televisions, washers, dryers, lights (inside and/or outside the structure **150**), stereos, intercom systems, garage-door openers, floor fans, ceiling fans, whole-house fans, wall air conditioners, pool heaters **114**, irrigation systems **116**, security systems (including security system components such as cameras, motion detectors and window/door sensors), and so forth. While descriptions of FIG. **1** can identify specific sensors and functionalities associated with specific devices, it will be appreciated that any of a variety of sensors and functionalities (such as those described throughout the specification) can be integrated into the device.

In addition to containing processing and sensing capabilities, each of the devices **102**, **104**, **106**, **108**, **110**, **112**, **114** and **116** can be capable of data communications and information sharing with any other of the devices **102**, **104**, **106**, **108**, **110**, **112**, **114** and **116**, as well as to any cloud server or any other device that is network-connected anywhere in the world. The devices can send and receive communications via any of a variety of custom or standard wireless protocols (Wi-Fi, ZigBee, 6LoWPAN, etc.) and/or any of a variety of custom or standard wired protocols (CAT6 Ethernet, HomePlug, etc.). The wall plug interfaces **110** can serve as wireless or wired repeaters, and/or can function as bridges between (i) devices plugged into AC outlets and communicating using Homeplug or other power line protocol, and (ii) devices that not plugged into AC outlets.

For example, a first device can communicate with a second device via a wireless router **160**. A device can further communicate with remote devices via a connection to a network, such as the Internet **162**. Through the Internet **162**, the device can communicate with a central server or a cloud-computing system **164**. The central server or cloud-computing system **164** can be associated with a manufacturer, support entity or service provider associated with the device. For one embodiment, a user may be able to contact customer support using a device itself rather than needing to use other communication means such as a telephone or Internet-connected computer. Further, software updates can be automatically sent from the central server or cloud-computing system **164** to devices (e.g., when available, when purchased, or at routine intervals).

By virtue of network connectivity, one or more of the smart-home devices of FIG. **1** can further allow a user to interact with the device even if the user is not proximate to the device. For example, a user can communicate with a device using a computer (e.g., a desktop computer, laptop computer, or tablet) or other portable electronic device (e.g., a smartphone). A webpage or app can be configured to receive communications from the user and control the device based on the communications and/or to present information about the device's operation to the user. For example, the user can view a current setpoint temperature for a device and adjust it using a computer. The user can be in the structure during this remote communication or outside the structure.

The smart home also can include a variety of non-communicating legacy appliances **140**, such as old conventional washer/dryers, refrigerators, and the like which can be controlled, albeit coarsely (ON/OFF), by virtue of the wall plug interfaces **110**. The smart home can further include a variety of partially communicating legacy appliances **142**, such as IR-controlled wall air conditioners or other IR-controlled devices, which can be controlled by IR signals provided by the hazard detection units **104** or the light switches **108**.

FIG. **2** illustrates a network-level view of an extensible devices and services platform with which the smart home of FIG. **1** can be integrated, according to some embodiments. Each of the intelligent, network-connected devices from FIG. **1** can communicate with one or more remote central servers or cloud computing systems **164**. The communication can be enabled by establishing connection to the Internet **162** either directly (for example, using 3G/4G connectivity to a wireless carrier), though a hubbed network (which can be scheme ranging from a simple wireless router, for example, up to and including an intelligent, dedicated whole-home control node), or through any combination thereof.

The central server or cloud-computing system **164** can collect operation data **202** from the smart home devices. For example, the devices can routinely transmit operation data or can transmit operation data in specific instances (e.g., when requesting customer support). The central server or cloud-computing architecture **164** can further provide one or more services **204**. The services **204** can include, e.g., software update, customer support, sensor data collection/logging, remote access, remote or distributed control, or use suggestions (e.g., based on collected operation data **204** to improve performance, reduce utility cost, etc.). Data associated with the services **204** can be stored at the central server or cloud-computing system **164** and the central server or cloud-computing system **164** can retrieve and transmit the data at an appropriate time (e.g., at regular intervals, upon receiving request from a user, etc.).

One salient feature of the described extensible devices and services platform, as illustrated in FIG. **2**, is a processing engines **206**, which can be concentrated at a single server or distributed among several different computing entities without limitation. Processing engines **206** can include engines configured to receive data from a set of devices (e.g., via the Internet or a hubbed network), to index the data, to analyze the data and/or to generate statistics based on the analysis or as part of the analysis. The analyzed data can be stored as derived data **208**. Results of the analysis or statistics can thereafter be transmitted back to a device providing ops data used to derive the results, to other devices, to a server providing a webpage to a user of the device, or to other non-device entities. For example, use statistics, use statistics relative to use of other devices, use patterns, and/or statistics summarizing sensor readings can be transmitted. The results or statistics can be provided via the Internet **162**. In this manner, processing engines **206** can be configured and programmed to derive a variety of useful information from the operational data obtained from the smart home. A single server can include one or more engines.

The derived data can be highly beneficial at a variety of different granularities for a variety of useful purposes, ranging from explicit programmed control of the devices on a per-home, per-neighborhood, or per-region basis (for example, demand-response programs for electrical utilities), to the generation of inferential abstractions that can assist on a per-home basis (for example, an inference can be drawn that the homeowner has left for vacation and so security detection equipment can be put on heightened sensitivity), to the generation of statistics and associated inferential abstractions that can be used for government or charitable purposes. For example, processing engines **206** can generate statistics about device usage across a population of devices and send the statistics to device users, service providers or other

entities (e.g., that have requested or may have provided monetary compensation for the statistics). As specific illustrations, statistics can be transmitted to charities **222**, governmental entities **224** (e.g., the Food and Drug Administration or the Environmental Protection Agency), academic institutions **226** (e.g., university researchers), businesses **228** (e.g., providing device warranties or service to related equipment), or utility companies **230**. These entities can use the data to form programs to reduce energy usage, to preemptively service faulty equipment, to prepare for high service demands, to track past service performance, etc., or to perform any of a variety of beneficial functions or tasks now known or hereinafter developed.

FIG. **3** illustrates an abstracted functional view of the extensible devices and services platform of FIG. **2**, with particular reference to the processing engine **206** as well as the devices of the smart home. Even though the devices situated in the smart home will have an endless variety of different individual capabilities and limitations, they can all be thought of as sharing common characteristics in that each of them is a data consumer **302** (DC), a data source **304** (DS), a services consumer **306** (SC), and a services source **308** (SS). Advantageously, in addition to providing the essential control information needed for the devices to achieve their local and immediate objectives, the extensible devices and services platform can also be configured to harness the large amount of data that is flowing out of these devices. In addition to enhancing or optimizing the actual operation of the devices themselves with respect to their immediate functions, the extensible devices and services platform can also be directed to "repurposing" that data in a variety of automated, extensible, flexible, and/or scalable ways to achieve a variety of useful objectives. These objectives may be predefined or adaptively identified based on, e.g., usage patterns, device efficiency, and/or user input (e.g., requesting specific functionality).

For example, FIG. **3** shows processing engine **206** as including a number of paradigms **310**. Processing engine **206** can include a managed services paradigm **310***a* that monitors and manages primary or secondary device functions. The device functions can include ensuring proper operation of a device given user inputs, estimating that (e.g., and responding to) an intruder is or is attempting to be in a dwelling, detecting a failure of equipment coupled to the device (e.g., a light bulb having burned out), implementing or otherwise responding to energy demand response events, or alerting a user of a current or predicted future event or characteristic. Processing engine **206** can further include an advertising/communication paradigm **310***b* that estimates characteristics (e.g., demographic information), desires and/or products of interest of a user based on device usage. Services, promotions, products or upgrades can then be offered or automatically provided to the user. Processing engine **206** can further include a social paradigm **310***c* that uses information from a social network, provides information to a social network (for example, based on device usage), processes data associated with user and/or device interactions with the social network platform. For example, a user's status as reported to their trusted contacts on the social network could be updated to indicate when they are home based on light detection, security system inactivation or device usage detectors. As another example, a user may be able to share device-usage statistics with other users. Processing engine **206** can include a challenges/rules/compliance/rewards paradigm **310***d* that informs a user of challenges, rules, compliance regulations and/or rewards and/or that uses operation data to determine whether a challenge has been met, a rule or regulation has been complied with and/or a reward has been earned. The challenges, rules or regulations can relate to efforts to conserve energy, to live safely (e.g., reducing exposure to toxins or carcinogens), to conserve money and/or equipment life, to improve health, etc.

Processing engine can integrate or otherwise utilize extrinsic information **316** from extrinsic sources to improve the functioning of one or more processing paradigms. Extrinsic information **316** can be used to interpret operational data received from a device, to determine a characteristic of the environment near the device (e.g., outside a structure that the device is enclosed in), to determine services or products available to the user, to identify a social network or social-network information, to determine contact information of entities (e.g., public-service entities such as an emergency-response team, the police or a hospital) near the device, etc., to identify statistical or environmental conditions, trends or other information associated with a home or neighborhood, and so forth.

An extraordinary range and variety of benefits can be brought about by, and fit within the scope of, the described extensible devices and services platform, ranging from the ordinary to the profound. Thus, in one "ordinary" example, each bedroom of the smart home can be provided with a smoke/fire/CO alarm that includes an occupancy sensor, wherein the occupancy sensor is also capable of inferring (e.g., by virtue of motion detection, facial recognition, audible sound patterns, etc.) whether the occupant is asleep or awake. If a serious fire event is sensed, the remote security/monitoring service or fire department is advised of how many occupants there are in each bedroom, and whether those occupants are still asleep (or immobile) or whether they have properly evacuated the bedroom. While this is, of course, a very advantageous capability accommodated by the described extensible devices and services platform, there can be substantially more "profound" examples that can truly illustrate the potential of a larger "intelligence" that can be made available. By way of perhaps a more "profound" example, the same data bedroom occupancy data that is being used for fire safety can also be "repurposed" by the processing engine **206** in the context of a social paradigm of neighborhood child development and education. Thus, for example, the same bedroom occupancy and motion data discussed in the "ordinary" example can be collected and made available for processing (properly anonymized) in which the sleep patterns of schoolchildren in a particular ZIP code can be identified and tracked. Localized variations in the sleeping patterns of the schoolchildren may be identified and correlated, for example, to different nutrition programs in local schools.

FIG. **4** is a schematic diagram of an HVAC system, according to some embodiments. HVAC system **103** provides heating, cooling, ventilation, and/or air handling for an enclosure, such as structure **150** depicted in FIG. **1**. System **103** depicts a forced air type heating and cooling system, although according to other embodiments, other types of HVAC systems could be used such as radiant heat based systems, heat-pump based systems, and others.

For carrying out the heating function, heating coils or elements **442** within air handler **440** provide a source of heat using electricity or gas via line **436**. Cool air is drawn from the enclosure via return air duct **446** through filter **470**, using fan **438** and is heated through heating coils or elements **442**. The heated air flows back into the enclosure at one or more locations via supply air duct system **452** and supply air registers such as register **450**. In cooling, an outside com-

pressor **430** passes a gas such as Freon through a set of heat exchanger coils and then through an expansion valve. The gas then goes through line **432** to the cooling coils or evaporator coils **434** in the air handler **440** where it expands, cools and cools the air being circulated via fan **438**. A humidifier **454** may optionally be included in various embodiments that returns moisture to the air before it passes through duct system **452**. Although not shown in FIG. **4**, alternate embodiments of HVAC system **103** may have other functionality such as venting air to and from the outside, one or more dampers to control airflow within the duct system **452** and an emergency heating unit. Overall operation of HVAC system **103** is selectively actuated by control electronics **412** communicating with thermostat **102** over control wires **448**.

FIGS. **5**A-**5**D illustrate a thermostat having a visually pleasing, smooth, sleek and rounded exterior appearance while at the same time including one or more sensors for detecting occupancy and/or users, according to some embodiments. FIG. **5**A is front view, FIG. **5**B is a bottom elevation, FIG. **5**C is a right side elevation, and FIG. **5**D is prospective view of thermostat **102**. Unlike many prior art thermostats, thermostat **102** has a sleek, simple, uncluttered and elegant design that does not detract from home decoration, and indeed can serve as a visually pleasing centerpiece for the immediate location in which it is installed. Moreover, user interaction with thermostat **102** is facilitated and greatly enhanced over known conventional thermostats by the design of thermostat **102**. The thermostat **102** includes control circuitry and is electrically connected to an HVAC system **103**, such as is shown in FIGS. **1**-**4**. Thermostat **102** is wall mountable, is circular in shape, and has an outer rotatable ring **512** for receiving user input. Thermostat **102** is circular in shape in that it appears as a generally disk-like circular object when mounted on the wall. Thermostat **102** has a large convex rounded front face lying inside the outer ring **512**. According to some embodiments, thermostat **102** is approximately 80 mm in diameter and protrudes from the wall, when wall mounted, by 32 mm. The outer rotatable ring **512** allows the user to make adjustments, such as selecting a new setpoint temperature. For example, by rotating the outer ring **512** clockwise, the realtime (i.e. currently active) setpoint temperature can be increased, and by rotating the outer ring **512** counterclockwise, the realtime setpoint temperature can be decreased. The front face of the thermostat **102** comprises a clear cover **514** that according to some embodiments is polycarbonate, and a Fresnel lens **510** having an outer shape that matches the contours of the curved outer front face of the thermostat **102**. According to some embodiments, the Fresnel lens elements are formed on the interior surface of the Fresnel lens piece **510** such that they are not obviously visible by viewing the exterior of the thermostat **102**. Behind the Fresnel lens is a passive infrared sensor **550** for detecting occupancy, and the Fresnel lens piece **510** is made from a high-density polyethylene (HDPE) that has an infrared transmission range appropriate for sensitivity to human bodies. As shown in FIGS. **5**A-**5**D, the front edge of rotating ring **512**, front face **514** and Fresnel lens **510** are shaped such that they together form a, integrated convex rounded front face that has a common outward arc or spherical shape gently arcing outward.

Although being formed from a single lens-like piece of material such as polycarbonate, the cover **514** has two different regions or portions including an outer portion **514***o* and a central portion **514***i*. According to some embodiments, the cover **514** is painted or smoked around the outer portion **514***o*, but leaves the central portion **514***i* visibly clear so as to facilitate viewing of an electronic display **516** disposed thereunderneath. According to some embodiments, the curved cover **514** acts as a lens that tends to magnify the information being displayed in electronic display **516** to users. According to some embodiments the central electronic display **516** is a dot-matrix layout (i.e. individually addressable) such that arbitrary shapes can be generated, rather than being a segmented layout. According to some embodiments, a combination of dot-matrix layout and segmented layout is employed. According to some embodiments, central display **516** is a backlit color liquid crystal display (LCD). An example of information displayed on the electronic display **516** is illustrated in FIG. **5**A, and includes central numerals **520** that are representative of a current setpoint temperature. The thermostat **102** is preferably constructed such that the electronic display **516** is at a fixed orientation and does not rotate with the outer ring **512**, so that the electronic display **516** remains easily read by the user. For some embodiments, the cover **514** and Fresnel lens **510** also remain at a fixed orientation and do not rotate with the outer ring **512**. According to one embodiment in which the diameter of the thermostat **102** is about 80 mm, the diameter of the electronic display **516** is about 45 mm. According to some embodiments the gently outwardly curved shape of the front surface of thermostat **102**, which is made up of cover **514**, Fresnel lens **510** and the front facing portion of ring **512**, is spherical, and matches a sphere having a radius of between 100 mm and 150 mm. According to some embodiments, the radius of the spherical shape of the thermostat front is about 136 mm.

Motion sensing with PIR sensor **550** as well as other techniques can be used in the detection and/or predict of occupancy, as is described further in the commonly assigned U.S. Ser. No. 12/881,430, which is incorporated herein by reference. According to some embodiments, occupancy information is used in generating an effective and efficient scheduled program. A second downwardly-tilted PIR sensor **552** is provided to detect an approaching user. The proximity sensor **552** can be used to detect proximity in the range of about one meter so that the thermostat **102** can initiate "waking up" when the user is approaching the thermostat and prior to the user touching the thermostat. Such use of proximity sensing is useful for enhancing the user experience by being "ready" for interaction as soon as, or very soon after the user is ready to interact with the thermostat. Further, the wake-up-on-proximity functionality also allows for energy savings within the thermostat by "sleeping" when no user interaction is taking place our about to take place.

According to some embodiments, for the combined purposes of inspiring user confidence and further promoting visual and functional elegance, the thermostat **102** is controlled by only two types of user input, the first being a rotation of the outer ring **512** as shown in FIG. **5**A (referenced hereafter as a "rotate ring" or "ring rotation" input), and the second being an inward push on head unit **540** until an audible and/or tactile "click" occurs (referenced hereafter as an "inward click" or simply "click" input). For such embodiments, the head unit **540** is an assembly that includes all of the outer ring **512**, cover **514**, electronic display **516**, and the Fresnel lens **510**. When pressed inwardly by the user, the head unit **540** travels inwardly by a small amount, such as 0.5 mm, against an interior metallic dome switch (not shown), and then springably travels back outwardly by that same amount when the inward pressure is released, providing a satisfying tactile "click" sensation to the user's hand, along with a corresponding gentle audible clicking sound.

Thus, for the embodiment of FIGS. **5**A-**5**D, an inward click can be achieved by direct pressing on the outer ring **512** itself, or by indirect pressing of the outer ring by virtue of providing inward pressure on the cover **514**, lens **510**, or by various combinations thereof. For other embodiments, the thermostat **102** can be mechanically configured such that only the outer ring **512** travels inwardly for the inward click input, while the cover **514** and lens **510** remain motionless. It is to be appreciated that a variety of different selections and combinations of the particular mechanical elements that will travel inwardly to achieve the "inward click" input are within the scope of the present teachings, whether it be the outer ring **512** itself, some part of the cover **514**, or some combination thereof. However, it has been found particularly advantageous to provide the user with an ability to quickly go back and forth between registering "ring rotations" and "inward clicks" with a single hand and with minimal amount of time and effort involved, and so the ability to provide an inward click directly by pressing the outer ring **512** has been found particularly advantageous, since the user's fingers do not need to be lifted out of contact with the device, or slid along its surface, in order to go between ring rotations and inward clicks. Moreover, by virtue of the strategic placement of the electronic display **516** centrally inside the rotatable ring **512**, a further advantage is provided in that the user can naturally focus their attention on the electronic display throughout the input process, right in the middle of where their hand is performing its functions. The combination of intuitive outer ring rotation, especially as applied to (but not limited to) the changing of a thermostat's setpoint temperature, conveniently folded together with the satisfying physical sensation of inward clicking, together with accommodating natural focus on the electronic display in the central midst of their fingers' activity, adds significantly to an intuitive, seamless, and downright fun user experience. Further descriptions of advantageous mechanical user-interfaces and related designs, which are employed according to some embodiments, can be found in U.S. Ser. Nos. 13/033,573, 29/386,021, and 13/199,108, all of which are incorporated herein by reference.

FIGS. **5**B and **5**C are bottom and right side elevation views of the thermostat **102**, which has been found to provide a particularly pleasing and adaptable visual appearance when viewed against a variety of different wall colors and wall textures in a variety of different home environments and home settings. While the thermostat itself will functionally adapt to the user's schedule as described herein and in one or more of the commonly assigned incorporated applications, the outer shape is specially configured to convey a "chameleon" quality or characteristic such that the overall device appears to naturally blend in, in a visual and decorative sense, with many of the most common wall colors and wall textures found in home and business environments, at least in part because it will appear to assume the surrounding colors and even textures when viewed from many different angles.

According to some embodiments, the thermostat **102** includes a processing system **560**, display driver **564** and a wireless communications system **566**. The processing system **560** is adapted to cause the display driver **564** and display **516** to display information to the user, and to receiver user input via the rotatable ring **512**. The processing system **560**, according to some embodiments, is capable of carrying out the governance of the operation of thermostat **102** including various user interface features. The processing system **560** is further programmed and configured to carry out other operations as described further hereinbelow and/or in other ones of the commonly assigned incorporated applications. For example, processing system **560** is further programmed and configured to maintain and update a thermodynamic model for the enclosure in which the HVAC system is installed, such as described in U.S. Ser. No. 12/881,463, and in International Patent App. No. PCT/US11/51579, both of which are incorporated herein by reference. According to some embodiments, the wireless communications system **566** is used to communicate with devices such as personal computers and/or other thermostats or HVAC system components, which can be peer-to-peer communications, communications through one or more servers located on a private network, or and/or communications through a cloud-based service.

According to some embodiments, for ease of installation, configuration and/or upgrading, especially by a non-expert installer such as a user, the thermostat **102** includes a head unit **540** and a backplate (or wall dock) **542**. As is described hereinabove, thermostat **102** is wall mounted and has circular in shape and has an outer rotatable ring **512** for receiving user input. Head unit **540** of thermostat **102** is slidably mountable onto back plate **542** and slidably detachable therefrom. According to some embodiments the connection of the head unit **540** to backplate **542** can be accomplished using magnets, bayonet, latches and catches, tabs or ribs with matching indentations, or simply friction on mating portions of the head unit **540** and backplate **542**. Also shown in FIG. **5**A is a rechargeable battery **522** that is recharged using recharging circuitry **524** that uses power from backplate that is either obtained via power harvesting (also referred to as power stealing and/or power sharing) from the HVAC system control circuit(s) or from a common wire, if available, as described in further detail in co-pending patent application U.S. Ser. Nos. 13/034,674, and 13/034,678, which are incorporated by reference herein. According to some embodiments, rechargeable battery **522** is a single cell lithium-ion, or a lithium-polymer battery.

FIGS. **6**A-**6**P illustrate aspects of a graphical user interface on small format touch-screen device for a network connected programmable thermostat, according to some embodiments. In FIG. **6**A, smartphone **600** is shown as an iPhone 4s running the Apple iOS operating system, although according to other embodiments the smartphone **600** could be a different device running a different operating system such as Android, Symbian, RIM, or Windows operating systems. Smart phone **600** has a touch sensitive display **610** on which various types of information can be shown and from which various types of user input can be received. For the example shown of an iPhone 4s, the display **610** is 3.5 inches measured diagonally. However, other smartphones may have slightly smaller, or larger displays, for example the iPhone 5 (4 inch diagonal), Samsung Galaxy S3 (4.8 inch diagonal), and Samsung Galaxy Note (5.3 inch diagonal). In any case the relatively small size of the smartphone touch screen display presents a challenge when designing a user-friendly interface. Note that while the user's hand **602** is shown in FIG. **6**A to scale, in subsequent drawings, the user's hand is shown smaller in order not to overly obscure the features being described herein.

The display area shows a top information bar **620** that is generated by and is standard to the operating system of the phone **600**. In FIGS. **6**A and **6**B, the smart phone is oriented in a portrait orientation, such that the long edge of the display **610** is vertically oriented. An upper banner are **622** includes information such as the thermostat manufacture's logo, as well as the city name and current outdoor tempera-

ture for the location where the user's thermostat is installed. A main window area **630** shows a house symbol **632** with the name assigned in which thermostat is installed. A thermostat symbol **634** is also displayed along with the name assigned to the thermostat. For further details of user interfaces for remote devices such as smartphone **600**, see co-pending U.S. patent application Ser. No. 13/317,423, and 13/434,560, both of which are incorporated herein by reference. In response to a user touching the thermostat icon **634**, an animated transition is made to display icon **636** which is larger than the icon **634** and is configured to mimic the display on the thermostat represented, including the current temperature shown in large central numerals, as well as the current setpoint temperature shown on a circular arrangement of tickmarks. For further details on aspects of the graphical user interface of thermostats, see U.S. Patent Publication No. 2012/0130546 A1, as well as commonly-assigned U.S. Pat. No. 8,195,313, both of which are incorporated by reference herein. When oriented in a portrait mode, according to some embodiments, a notification **638** is displayed that informs the user that further user interface features are available in landscape mode. When the user turns the smartphone **600** sideways, the screen transitions to a screen such as shown in FIG. **6**C.

In FIG. **6**C, a lower menu bar **640** has an arrow shape that points to the symbol to which the displayed menu applies. In the example shown in FIG. **6**C, the arrow shape of menu **640** is pointed at the thermostat symbol **634**, indicating that the menu items, namely: Energy, Schedule, and Settings, pertain to the thermostat named "living room." Menu **640** also includes an on/off toggle button **642** from which the user can turn off or on the thermostat. When the "Schedule" menu option of selected from menu **640** in FIG. **6**C by the user, the display **610** transitions to that shown in FIG. **6**D. In FIG. **6**D, an upper menu area **650** mimics the menu **640** in FIG. **6**C and provides the user location information within the menu structure as well as provides a convenient means for the user to navigate within the menu structure. The central display area **658** shows the various programmed setpoint temperatures laid out in a calendar format in which each row represents a day of the week, such as row **652** representing the setpoints for each Tuesday. For each day of the week, individual setpoints are represented by a colored disk with numerals indicating the setpoint temperature. The disk's horizontal position indicates the time of day that the setpoint becomes active, with the time labels being shown near the bottom of display area **658**. The colors of the disks indicate the type of HVAC function associated with the setpoint. According to some preferred embodiments, an orange color is associated with heating setpoints and a blue color is associated with cooling setpoints. To example setpoint icons **654** and **656** are shown for Tuesday. Note that in this example the schedule is a weekly schedule which is intended to repeat each week. According to some other embodiments, other types of program schedules can be accommodated by the user interface techniques described herein, including daily, by-weekly, monthly, seasonal, etc.

If the user wants to see more detail for a particular day of the week, the user touches somewhere on the row for that day. For example in FIG. **6**D a user is touching the row **652** for Tuesday. Note that according to some embodiments, the user can touch the label "Tuesday" or anywhere else on the row **652** to transition to a more detailed view for that day, which is shown in FIG. **6**E. In FIG. **6**E the central area **662** displays setpoints for the day of the week, Tuesday, on a detailed two-dimensional graph in which the horizontal axis represents the time of day the setpoint becomes active and the vertical axis represents the temperature associated with the setpoint. As in the case of FIG. **6**D, each setpoint disk has numerals indicating the setpoint temperature, as well as a color indicating the type of HVAC function (e.g. heating or cooling) associated with the setpoint. Also shown in FIG. **6**E is a lower menu area **660** that includes menu items "WEEK" for returning to the weekly display as shown in FIG. **6**D, "ADD" for adding a new setpoint; and "REMOVE" for removing an existing setpoint. For further details of user interface features relating to such schedule displays on remote devices, see U.S. patent application Ser. No. 13/275,311, filed Oct. 17, 2011, and U.S. Patent Application Publication No. 2012/0191257 A1, both of which are incorporated by reference herein.

When a user wishes to adjust a programmed setpoint (i.e. either adjusting the time or the setpoint temperature associated with the setpoint), the user touches and holds the disk icon for the setpoint. In FIG. **6**E, the user wishes to adjust setpoint **666** and is therefore touching that disk. In response, as shown in FIG. **6**F, a setpoint modification user interface mode is activated. A large disk **672** is displayed directly above the original setpoint disk position. The large disk **672** initially shows in larger numerals the setpoint temperature currently associated with that setpoint (prior adjustment). Since the user's finger tends to block the information on the smaller disk being touched, the larger disk has been found to very helpful. The original disk **666** is replaced by a numberless disk symbol **674**, which is now underneath the user's fingertip. A cross-shaped two dimensional direction indicator **670** is displayed, such as by a darker shaded color, to indicated to the user that either the time or the temperature can be modified simply by a dragging motion with the user's finger. When editing a setpoint, it has been found that allowing the user to simply touch and drag the displayed setpoint disk icon is both intuitive and user friendly. Importantly, it has been found that in the vast majority of cases, when a user wishes to modify a setpoint, it is either to the time or the temperature of the setpoint, but not to both. Furthermore it has been found that for small format touch screen displays such as with a smart phone or tablet computer, when the user intends to modify only time or temperature, it is quite easy for the user to accidentally modify the other parameter. This is because on a small format touch screen device, relatively small movements can be used to make significant changes in the setpoint temperature and/or time. For example, on a smart phone display such as shown in FIG. **6**F, if the user intends to make a change in the setpoint temperature, the user will make a dragging gesture in a vertical direction. However if the dragging motion is even slightly diagonal rather then perfectly vertical, the user may accidentally also change the setpoint time by 15 minutes or more. Similarly, if the user intends to make a change in the setpoint time, the user will make a dragging gesture in a horizontal direction. However, if the dragging motion is even slightly diagonal rather than perfectly horizontal, the user may accidentally also change the setpoint temperature by one or more degrees. Accordingly, according to preferred embodiments, the user's adjustments to a setpoint are constrained to either time or temperature depending on a determination of the user's intent.

If the user wishes to adjust the temperature of the setpoint **666**, the user will make a dragging gesture, without lifting the finger off the screen **610**, in an upwards direction to increase the setpoint temperature and in a downwards direction to decrease the setpoint temperature. The user interface application (e.g. the mobile app) senses the vertical motion quickly transitions the screen to that shown in FIG. **6**G,

which will only allow changes to temperature and not to time. Note that the cross-shaped two-dimensional direction indicator **670** of FIG. **6**F is replaced by a vertical slider indictor **676** to indicate to the user that only temperature can be adjusted. Note that the large disk symbol **672** displays in real time the new setpoint temperature. When the user's desired new setpoint is shown in disk **672**, the user releases their finger from screen **610** and the new temperature is adopted for the setpoint, and the screen transitions to a format shown in FIG. **6**E. According to some embodiments, the setpoint temperature can be adjusted in increments of either one degree Fahrenheit, or half of one degree Celsius. According to some embodiments, a leaf symbol is displayed when the new setpoint would be worth of the leaf symbol, for example according to one or more algorithms such as described in co-pending U.S. patent application Ser. No. 13/434,560 filed Mar. 29, 2012, which is incorporated herein by reference.

However, starting again from FIG. **6**F, if the user wishes to modify the time associated with the setpoint (i.e. the time of day that the setpoint becomes active), user makes a dragging gesture to the right to make the setpoint activate later, or to the left to make the setpoint activate earlier. As soon as the user begins to drag their finger in a vertical direction, a determination is made that the user intends to modify the setpoint temperature and the screen is quickly transitioned to the screen as shown in FIG. **6**H, which will only allow changes to time and not to temperature. Note that the cross-shaped two-dimensional direction indicator **670** of FIG. **6**F is replaced by a horizontal slider indictor **678** to indicate to the user that only the time can be adjusted. According to some embodiments, the setpoint time can be adjusted in increments of 15 minutes. Note that the disk **672** now displays the new time to be associated with the setpoint. When the user sees the new desired time in disk **672**, such as shown FIG. **6**I, where the user wishes to the new setpoint time to be 8:30 AM, the user simply releases their finger from screen **610** and the new time is adopted for the setpoint, and the screen transitions to a format shown in FIG. **6**E. Note that in the rather uncommon case that a user wishes to modify both time and temperature for a setpoint, this can still be accomplished by first modifying one parameter and then the other as described.

FIG. **6**J shows aspects in determining a user's intention in adjusting a setpoint, according to some embodiments. To determine which parameter, time or temperature, the user wishes to adjust, the initial motion of the dragging gesture by the user's finder is analyzed. According to one embodiment, if the user's initial finger movement is within 45 degrees of a vertical direction, such as the case of direction arrow **692**, it is determined that the user intends to adjust the setpoint temperature, and if the user's initial finger movement is within 45 degrees of a horizontal direction, as in the case of direction arrow **690**, then it is determined that user intends to adjust the setpoint time. Other methods of determining can also be used, such as asking the user, in cases the initial movement is close to 45 degrees.

FIG. **6**K-**6**N show further aspects of a thermostat graphical user interface implemented on a small-format touch screen device, according to some embodiments. When the user double taps anywhere in the central area **662** of a single-day two-dimensional setpoint plot, such as shown in FIG. **6**K, a transition is smoothly and quickly made to a multi-day two-dimensional setpoint plot such as shown in FIG. **6**L, where central area **680** has a more compressed time scale than area **662** of the single-day plot shown in FIG. **6**K, such that it includes slightly less than 48 hours of setpoint information. A multi-day display can be useful, for example, when the user wishes to look setpoints or compare setpoints between several different days of the week. According to some embodiments, as shown in FIGS. **6**M and **6**N, a dragging gesture anywhere in the central area **680** scrolls the time line of the multi-day plot so that the user can quickly and intuitively view and modify (using the same procedure shown in FIGS. **6**E-**6**J) setpoints from various days of the week. According to some embodiments, the dragging-to-scroll functionality illustrated in FIGS. **6**M and **6**N are also operable when viewing a single-day plot such as in FIG. **6**K, and works in the same way except that the time scale is not compressed an still only shows 24 hours at at time.

FIGS. **6**O and **6**P show further aspects of a thermostat graphical user interface implemented on a small-format touch screen device, according to some embodiments. It has been found that many times a user makes detailed adjustments to all the setpoints of a given day of the week, and subsequently wishes to copy and paste those setpoints to one or more other days of the week. For example a good program schedule for Tuesday may also be a good for the other weekdays, namely Monday, Wednesday, Thursday and Friday. In such cases cutting and pasting setpoints from one day to another can easily be accomplished as shown in FIGS. **6**O and **6**P. By tapping and holding anywhere in a two-dimensional plot such as the single-day plot shown in FIG. **6**O, an option is given to "Copy" all the setpoints. According to some embodiments, all the setpoints for the day can be deleted using the "Clear Day" option. After a "Copy" option has been selected, the user can navigate to a the two-dimensional plot of a different day (for example using the double tap and drag gestures as shown in FIGS. **6**K-**6**N, or simply the dragging gesture). Then single tapping on any other day highlights that day (such as by shading the area corresponding to that day as shown in FIG. **6**P), and the option **684** to "Paste" the previously copied setpoints is given as shown in FIG. **6**P.

FIGS. **7**A-**7**D show aspects of a thermostat graphical user interface implemented on a small-format touch screen device pertaining to responsibility for setpoint changes and other events, according to some embodiments. Shown in FIG. **7**A is a detailed energy information screen, such as described in further detail in co-pending U.S. patent application Ser. No. 13/434,560, filed Mar. 29, 2012, which is incorporated by reference herein. Shown in the detailed time-line area **710** is a time-line bar **782** for the entire day with hash marks or symbols for each two hours. The main bar **782** is used to indicate the times during the day and duration of each time the HVAC function was active. The color of the horizontal activity bar, such as bar **786** matches the HVAC function being used, and the width of the activity bar corresponds to the time of day during which the function was active. According to some embodiments the thermostat and HVAC system are capable of up to three stages of heating and two stages of cooling, and the activity bars are color coded to show which stages were active during which times. For example, progressively more saturated colors or orange-red can be used for each more power stage of heat, such as salmon for first stage heat, orange for second stage heat and red-orange for third stage heat. Likewise light and dark blue can be used for first and second stage cooling respectively.

Also shown on the detailed time-line area **710** are a number of event symbols such as setpoint disk **712** which indicates that setpoint of 70 degrees was activated at about 11 AM on Saturday, February 25th. According to some embodiments, touching the event symbol **712** by the user

activate an information bubble **714** that shows the user information as to the setpoint. In this case, the setpoint was set using a mobile app. on a smartphone identified as "Kate's iPhone." In the case shown in FIG. **7**B, the event symbol **722** represents a setpoint of 63 degrees. The user's selection of the setpoint **722** causes the information bubble **724** to be displayed which indicates that that setpoint was set by "Nest Learning" which is an automated learning algorithm that can set and adjust setpoints to enhance comfort as well as cost savings. For further detail on learning algorithms for establishing and/or adjusting setpoints based on either real-time manual adjustments (meaning the user wishes to adjust the current temperature) and non-real-time manual adjustments (meaning the user wishes to adjust a programmed setpoint), see, U.S. Provisional Patent Application Ser. No. 61/550,346, filed Oct. 21, 2011, and International Patent Publication No. WO 2012/068591, both of which are incorporated herein by reference. In the example shown in FIG. **7**C, the away event symbol is selected by the user, which causes the information bubble **734** to be displayed. In this case the away mode was set manually by a user. In other cases an away mode can be initiated by an "auto-away" algorithm such as described in further detail in U.S. Patent Application Publication No. US 2012/0186774 A1, which is incorporate by reference herein. In such cases the information bubble can read, for example "Away Mode Set Automatically by Auto-Away." While the setpoints shown in the historical energy display of FIGS. **7**A-**7**B were actual setpoints that were either scheduled or manually initiated, according to some embodiments, similar information can be displayed for scheduled setpoints. Shown in FIG. **7**D is a two-dimensional setpoint plot. In response to the user double tapping a setpoint disk **742**, the information bubble **744** is displayed that indicates that a smart phone identified as "Bill's iPhone" was used to create, or most recently modify that setpoint.

FIGS. **8**A-**8**B show aspects of a thermostat graphical user interface implemented on a tablet computer with a touch screen device, according to some embodiments. Each of the features described herein with respect to a smart phone touch screen device, can also be implemented on larger touch screen devices such as a tablet computer. For example, in FIG. **8**A, an iPad **800** is running the Apple iOS operating system, although according to other embodiments the tablet **800** could be a different device running a different operating system such as the Android, Blackberry or Windows operating systems. Tablet **800** has a touch sensitive display **810** on which various types of information can be shown and from which various types of user input can be received. The display area shows a top information bar **820** that is generated by and is standard to the operating system of the tablet **800**. A main window area **830** shows a house symbol **832** with the name assigned in which thermostat is installed. A thermostat symbol **834** is also displayed along with the name assigned to the thermostat. For further details of user interfaces for remote devices such as tablet **800**, see co-pending U.S. patent application Ser. No. 13/317,423, which is incorporated herein by reference. The lower menu bar **850** has an arrow shape that points to the symbol to which the displayed menu applies. In the example shown in FIG. **8**A, arrow shape of menu **850** is pointed at the thermostat logo **834**, so the menu items, namely: Energy, Schedule, and Settings, pertain to the thermostat named "living room." In the lower display area **862** a two-dimensional setpoint plot is shown wherein the user is making an adjustment to the setpoint symbol at location **874** as shown by the cross-shaped two-dimensional direction indicator **870**. A large disk **872** is also displayed as described infra with respect to FIG. **6**F. In FIG. **8**B, historical energy information is being displayed in the lower area **860**. In response to the user selecting a setpoint event symbol **822**, the information bubble **824** is displayed that indicates the setpoint was set by a smart phone identified as "Bill's iPhone."

Although the concepts relating to user interfaces for small format touch screens have been thus far described with respect to a thermostat, according to some embodiments these concepts are applicable beyond the immediate environment of HVAC to the smart home as a whole, as well as to network-based ecosystems within which the invention may be applicable. Other applications in a smart home setting, such as shown in FIG. **1**, for the described small format touch screen settings using constrained variables includes: irrigation settings (where a user may want to edit either days of the week and watering time on a small format touch screen display), as well as home electronics settings such as televisions, stereos, etc.

Applications in a smart home, such as shown in FIG. **1**, for the described setpoint responsibility indicator includes other settings where it would useful for a user to know who and/or when a settings was established or adjusted. Such applications include pool/spa heater adjustments, and settings with appliances such as refrigerators and/or freezers.

Various modifications may be made without departing from the spirit and scope of the invention. It is to be further appreciated that the term thermostat, as used hereinabove and hereinbelow, can include thermostats having direct control wires to an HVAC system, and can further include thermostats that do not connect directly with the HVAC system, but that sense an ambient temperature at one location in an enclosure and cooperatively communicate by wired or wireless data connections with a separate thermostat unit located elsewhere in the enclosure, wherein the separate thermostat unit does have direct control wires to the HVAC system. Accordingly, the invention is not limited to the above-described embodiments, but instead is defined by the appended claims in light of their full scope of equivalents.

What is claimed is:

1. A method of interactively and graphically displaying programmed setpoint information to a user of an HVAC system controlled by a thermostat, the method comprising:

receiving and storing, by a mobile device, information indicating that a first setpoint change in a setpoint schedule was made on a user interface of the thermostat;

receiving and storing, by the mobile device, information indicating that a second setpoint change in the setpoint schedule was made by a first identified user;

displaying, on a display of the mobile device, a graphical daily summary of thermostat information for each of a plurality of days, the graphical daily summary including at least a first setpoint icon representing the first setpoint and a second setpoint icon representing the second setpoint;

receiving, by the mobile device, a selection of the displayed first setpoint icon;

displaying, on the display of the mobile device, information indicating that the first setpoint was changed by the user interface of the thermostat;

receiving, by the mobile device, a selection of the displayed second setpoint icon: and

displaying, on the display of the mobile device, information indicating that the second setpoint was changed by the first identified user.

2. The method according to claim 1 wherein a plurality of predefined ways in which setpoints can be generated and/or adjusted includes one or more of the following selected from a group consisting of: by a user on the thermostat, by a user on the mobile device, by a user using a web application, and by an automated learning algorithm.

3. The method according to claim 2 wherein a way in which the first setpoint was generated and/or adjusted is by a user on a mobile device, and the displayed information indicating the way in which the first setpoint was generated and/or adjusted includes an identification of a name associated with the mobile device.

4. The method according to claim 1 wherein the graphical daily summary includes a displayed away symbol indicating the thermostat activated an away mode, the method further comprising in response to receiving a selection of the displayed away symbol, displaying information indicating to the user whether the away mode was initiated by a user or automatically.

5. The method according to claim 1 wherein the mobile device comprises a smart phone.

6. The method according to claim 1 wherein the mobile device comprises a tablet computer.

7. The method according to claim 1 wherein the mobile device comprises part of personal computer system running a web-based application.

8. A non-transitory electronic storage medium comprising instructions that, when executed by one or more processors, cause the one or more processors to perform operations comprising:

receiving and storing, by a mobile device, information indicating that a first setpoint change in a setpoint schedule was made on a user interface of a thermostat;

receiving and storing, by the mobile device, information indicating that a second setpoint change in the setpoint schedule was made by a first identified user;

displaying, on a display of the mobile device, a graphical daily summary of thermostat information for each of a plurality of days, the graphical daily summary including at least a first setpoint icon representing the first setpoint and a second setpoint icon representing the second setpoint;

receiving, by the mobile device, a selection of the displayed first setpoint icon;

displaying, on the display of the mobile device, information indicating that the first setpoint was changed by the user interface of the thermostat;

receiving, by the mobile device, a selection of the displayed second setpoint icon; and

displaying, on the display of the mobile device, information indicating that the second setpoint was changed by the first identified user.

9. The non-transitory electronic storage medium of claim 8 wherein a plurality of predefined ways in which setpoints can be generated and/or adjusted includes one or more of the following selected from a group consisting of: by a user on the thermostat, by a user on the mobile device, by a user using a web application, and by an automated learning algorithm.

10. The non-transitory electronic storage medium of claim 9 wherein a way in which the first setpoint was generated and/or adjusted is by a user on a mobile device, and the displayed information indicating the way in which the first setpoint was generated and/or adjusted includes an identification of a name associated with the mobile device.

11. The non-transitory electronic storage medium of claim 8 wherein the graphical daily summary includes a displayed away symbol indicating the thermostat activated an away mode, wherein the instructions further cause the one or more processors to, in response to receiving a selection of the displayed away symbol, displaying information indicating to the user whether the away mode was initiated by a user or automatically.

12. The non-transitory electronic storage medium of claim 8 wherein the mobile device comprises a smart phone.

13. The non-transitory electronic storage medium of claim 8 wherein the mobile device comprises a tablet computer.

14. The non-transitory electronic storage medium of claim 8 wherein the mobile device comprises part of personal computer system running a web-based application.

15. A system comprising:

one or more processors;

a display device;

one or more memories comprising instructions that, when executed by the one or more processors, cause the one or more processors to perform operations comprising:

receiving and storing, by a mobile device, information indicating that a first setpoint change in a setpoint schedule was made on a user interface of a thermostat;

receiving and storing, by the mobile device, information indicating that a second setpoint change in the setpoint schedule was made by a first identified user;

displaying, on a display of the mobile device, a graphical daily summary of thermostat information for each of a plurality of days, the graphical daily summary including at least a first setpoint icon representing the first setpoint and a second setpoint icon representing the second setpoint;

receiving, by the mobile device, a selection of the displayed first setpoint icon;

displaying, on the display of the mobile device, information indicating that the first setpoint was changed by the user interface of the thermostat;

receiving, by the mobile device, a selection of the displayed second setpoint icon; and

displaying, on the display of the mobile device, information indicating that the second setpoint was changed by the first identified user.

16. The system of claim 15 wherein a plurality of predefined ways in which setpoints can be generated and/or adjusted includes one or more of the following selected from a group consisting of: by a user on the thermostat, by a user on the mobile device, by a user using a web application, and by an automated learning algorithm.

17. The system of claim 16 wherein a way in which the first setpoint was generated and/or adjusted is by a user on a mobile device, and the displayed information indicating the way in which the first setpoint was generated and/or adjusted includes an identification of a name associated with the mobile device.

18. The system of claim 17 wherein the graphical daily summary includes a displayed away symbol indicating the thermostat activated an away mode, wherein the instructions further cause the one or more processors to, in response to receiving a selection of the displayed away symbol, displaying information indicating to the user whether the away mode was initiated by a user or automatically.

19. The system of claim 17 wherein the mobile device comprises a smart phone.

20. The system of claim **17** wherein the mobile device comprises part of personal computer system running a web-based application.

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